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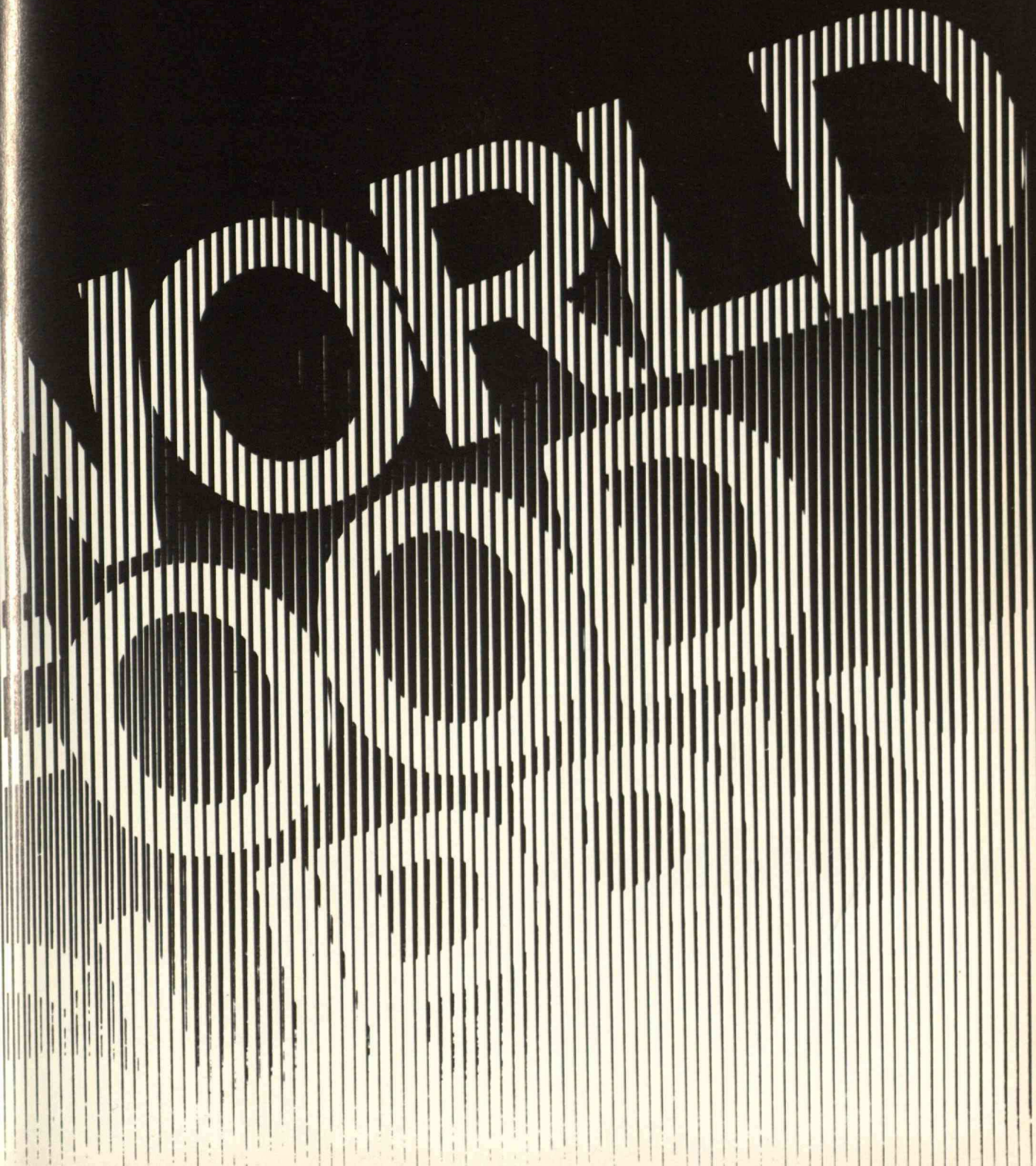

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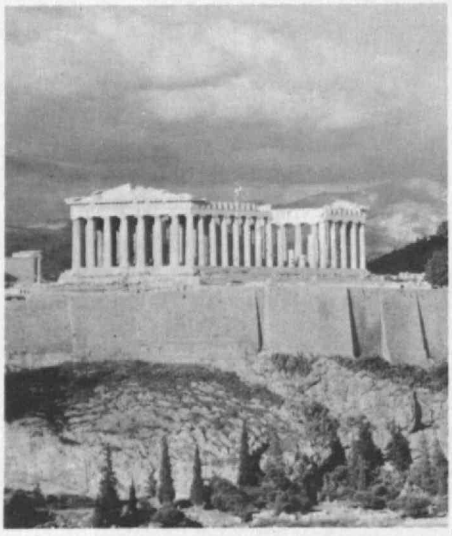

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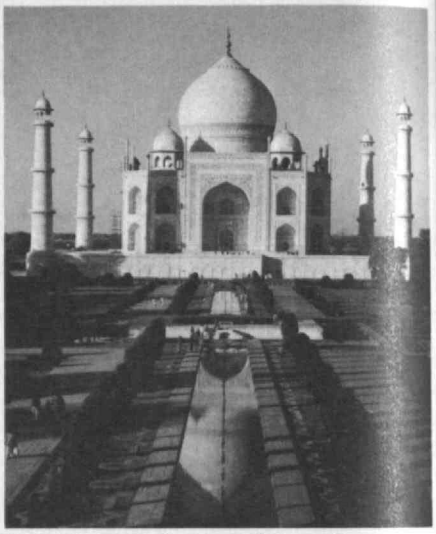

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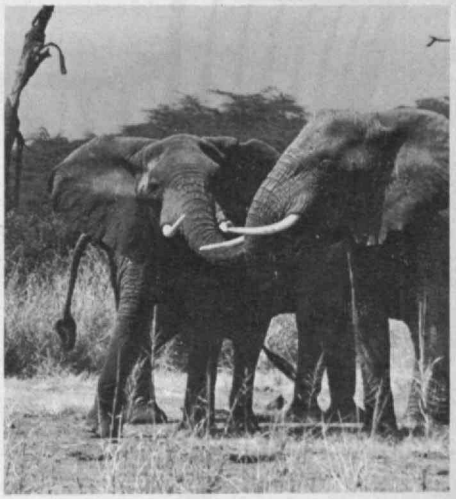

pink flamingos at LAKE NAKURU; multitudes of lion, zebra, wildebeest and other plains game in the MASAI-MARA RESERVE and the famed SERENGETI PLAINS; the great permanent concentrations of wildlife in the NGORONGORO CRATER; tree-climbing lions along the shores of LAKE MANYARA in the Rift Valley, photographing rhino and other big game against the majestic snow-covered background of Mt. Kilimanjaro in the AMBOSELI RESERVE; and the vast and fascinating wilderness of TSAVO NATIONAL PARK, renowned for its elephant and lion and for the unusual desert phenomenon of the Mzima Springs. There is also a stay in NAIROBI, the most fascinating city in East Africa, as well as features such as a visit to a MASAI MANYATTA to see tribal dancing and the tribal way of life. Total cost is $1799 from New York. Optional visits are available to the VICTORIA FALLS, to UGANDA, and to ETHIOPIA. Departures in January, February, March, May, June, July, August, September, October, November and December 1974 (extra air fare for departures in June, July and August).

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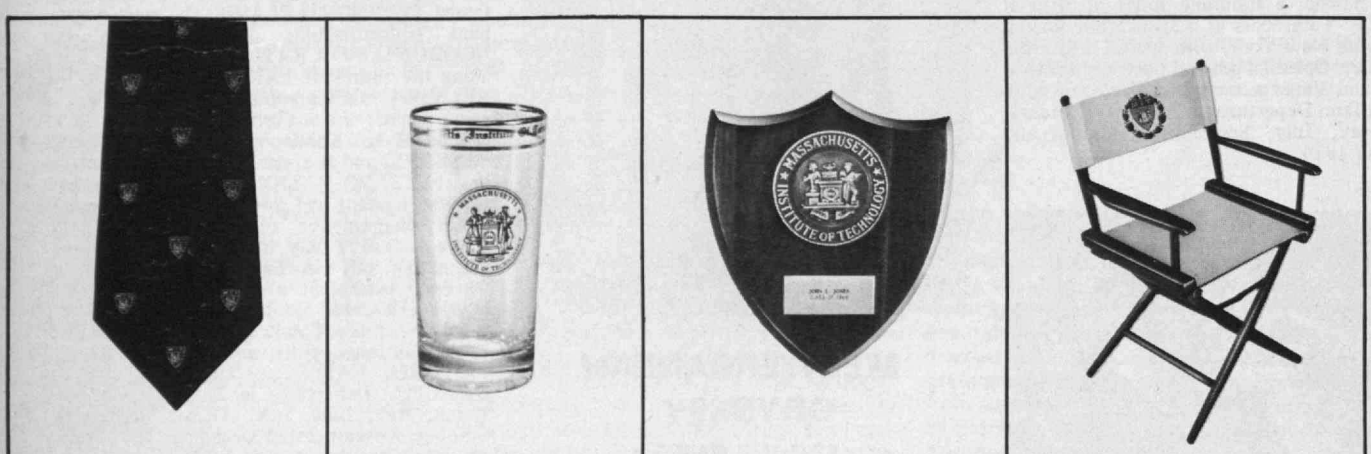

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Letters

What Priority for the Breeder?

In "The Breeder Reactor in the U.S.: A New Economic Analysis" (*July/August, pp. 26-36*) Irvin C. Bupp and Jean-Claude Derian fail to note important considerations which, in my opinion, considerably weaken the authors' negative assessment of the incentives for early development of breeder reactors:

—The cost of the nuclear steam supply system, the area in which most of the light water reactor (LWR) and breeder cost differences should be concentrated, is only about one-sixth of total plant cost. Thus the $125/kwe. cost penalty allowed by the authors (which also happens to be about one-sixth of total plant cost) *really* represents a 100 per cent cost differential between concepts—a not-so-preposterous obstacle to be overcome by the breeder. At the very least there are no grounds for implying that the land, turbine plant, switchyard, etc., for the breeder will be more expensive than corresponding LWR items.

—In contrast to their diverse thermal reactor programs of the past, almost all other major industrialized nations (Russia, Germany, Japan, France, Great Britain, etc.) have also decided (and unless knowledgeably contradicted, one would assume independently and with some degree of reasoned evaluation) that development of the liquid-metal-cooled fast breeder reactor (LMFBR) deserves top priority. Indeed, from all reports, the currently operating French demonstration plant, Phenix, has established a cost-effectiveness benchmark which already gives reasonable assurance of successful commercial prospects for the breeder. Bupp and Derian offer no rebuttal to this favorable foreign opinion and experience.

—No mention is made of alternate breeder concepts, especially the gas-cooled fast breeder (GCFR), which has a primary system design substantially different from that of the LMFBR, and therefore offers a much different approach to achieving capital cost equity with LWR's. The molten salt breeder (MSBR) offers still another fundamentally different route to competitiveness.

—Important synergistic effects enter in, which reduce the costs of a mixed economy of thermal and fast reactors. In particular, the breeder can easily produce (as excess fissile product in its radial blanket) ^{233}U, a premium fuel for all thermal reactors. General Atomic has shown, for example, that by this stratagem a system composed of one GCFR and three high-temperature gas-cooled reactors (HTGR) can be self-sustaining *without* recourse to uranium enrichment! Even without exercising this particular option, the breeder will help relieve a projected severe excess demand on enrichment capacity which will otherwise escalate future LWR fuel cycle costs.

Important technological considerations have been omitted from the analysis: LMFBR's operate at a primary system pressure of only 100 p.s.i. or so, while PWR reactors operate at around 2,200 p.s.i. Thus the LMFBR requires *much* thinner pressure vessels and piping—a factor which offers prospects for cheaper, rather than more expensive, plant costs in the long run. Attractive trade-offs can also be cited for the other breeder concepts: GCFR and MSBR. Indeed, all the breeder concepts have a significantly higher thermal efficiency than LWR's-hence lower waste heat disposal costs and environmental impact. Nowhere in the article is any analysis presented showing why the breeder *must inherently* be more expensive than a LWR. Novelty and "learning-curve" effects can be cited against any new system.

Michael J. Driscoll
Cambridge, Mass.

The writer is Associate Professor of Nuclear Engineering at M.I.T. Drs. Bupp and Derian respond:

Mr. Driscoll's comments focus mainly on the problem of the capital cost differential between present light water reactors (L.W.R.s) and future breeder reactors. Thus he provides us with the opportunity to discuss a point that, for space and editorial reasons, we did not develop in our article.

The issue is: On the basis of domestic construction experience with LWR technology, how confident can we be about the future costs of the breeder, a similar but essentially new technology? A related question is: How can foreign experience be taken into account?

The first point to be stressed is that for the past ten years in the United States there has been a systematic discrepancy, averaging a factor of two, between expected and actual costs (in constant dollars) of L.W.R.s There is *no* evidence that this discrepancy has begun to narrow. Indeed, contrary to experience with most industrial products, we have not as yet observed a "learning-by-doing" phenomenon in the nuclear reactor business. It is roughly true that L.W.R.s have been increasing in cost and still continue to do so today at the average rate of $30/kw./yr. in constant 1973 dollars.

In a separate paper ("Trends in Light Water Reactor Capital Costs in the U.S.," a report from the Center for Policy Alternatives, M.I.T., November, 1974) we and M. P. Donsimoni and R. Treitel have reviewed the capital cost experience of L.W.R.s in some detail and proposed an interpretation of it. The cost of a nuclear plant today has little to do with the cost of assembling different pieces of equipment and raw materials on a given site; it is rather highly dependent on the process by which these machines are licensed. The cost of the identical reactors on different sites is likely to vary widely according to licensing difficulties and the local intensity of nuclear opposition. The real question, therefore, with respect to the future cost of a new and similar product like the breeder is the response of the licensing process to the safety issues which may be raised. The cost history of L.W.R.s in the U.S. suggests that engineering estimates may be only a very weak guide, at best, to predicting the eventual capital costs of breeders. Ultimately, it is the perception that the public will have of this new technology and, as a consequence, the design criteria established by the licensing procedure that will determine the cost of a commercial breeder reactor. The questions and objections already raised by environmentalists during the recent debate on the environmental impact statement made by the Atomic Energy Committee

(*continued on p. 80*)

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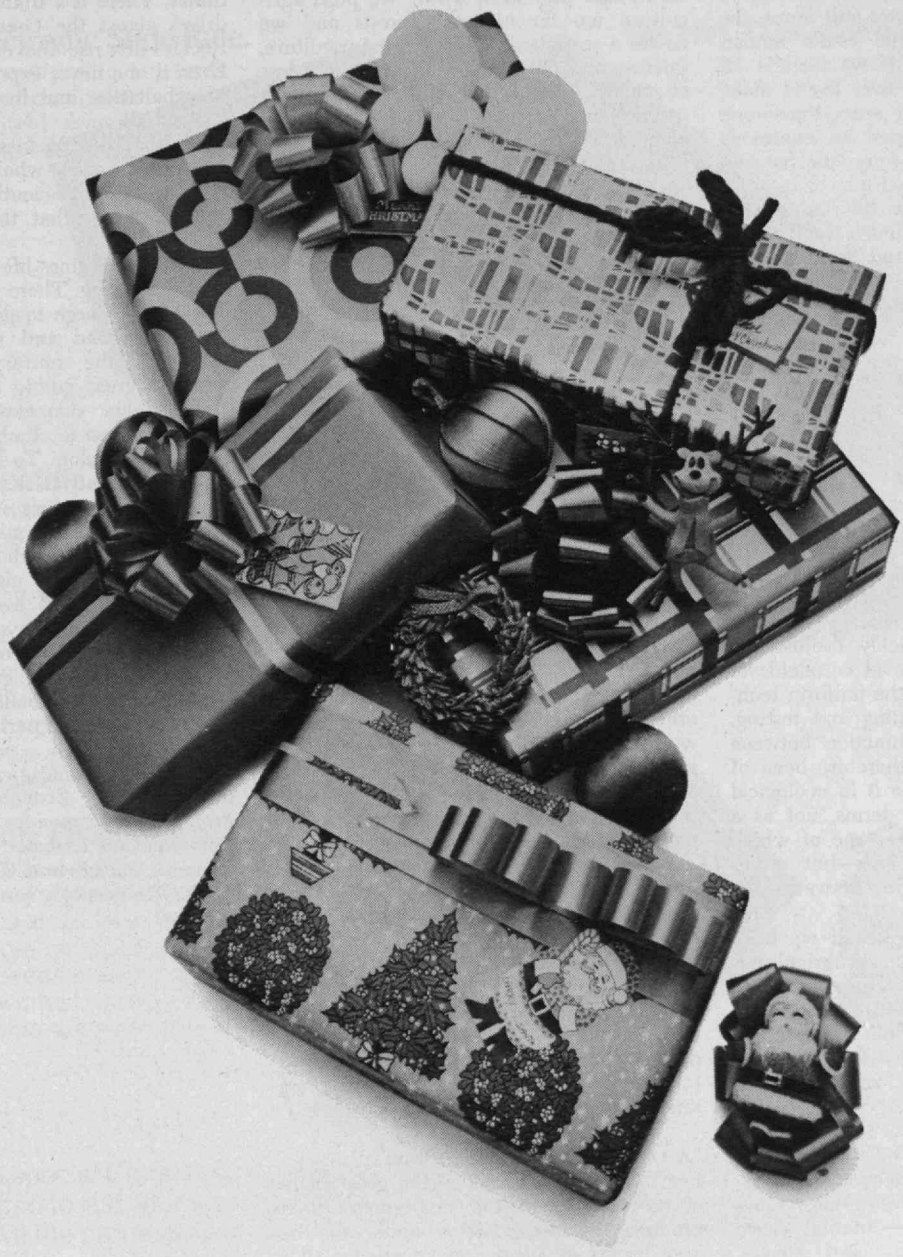

Plains of Science, Summits of Passion

Technology/Society
by
Kenneth E. Boulding

The 10 billion neurons of the individual human nervous system, and still more, the 3×10^{19} neurons of the whole human race (about 77×10^{19} if we include all human beings who have ever lived) make a very large habitat in space-time—one that has already developed an enormous complexity of mental species but has yet realized only a small proportion of its total potential. One thinks of this as a vast ecosystem populated by images and ideas, perceptions and beliefs, and one perceives science as a small, but very productive sub-ecosystem within this vast habitat. This scientific ecosystem is rather like the agriculture in the Middle West and the Great Plains, surrounded by a vast expanse of the meadows of ordinary experience, the lush forests of religion and art, and the wild glaciers and peaks of ecstacy and agony, mysticism and power, saint-hood and devilry.

I happen to live in a marginal ecosystem, where the Great Plains meet the Rocky Mountains and cactus blooms under the ponderosa pine. I have also lived most of my life on the uneasy margin between science and religion. Prickly cactuses of faith also bloom in the level cornfields of economics, cultivated by the uniform technologies of scientific planting and testing. The often conflicting interaction between science and religion has therefore been of great interest to me: I see it in ecological rather than in dialectical terms, not as a battle between two armies—one of which must win and the other lose—but rather like the wavering margin between the cornfield and the forest.

In the last century and a half we have seen an enormous expansion of agriculture, and the forest and the prairie everywhere have retreated before the relentless advance of the field. This is not unrelated to the similar advance in science, which is a kind of mental agriculture, and of government, which is political agriculture. Science raises periodic tables, testable equations, and mechanical and evolutionary models and routs out witchcraft and astrology, alchemy and old wives' tales. Government grows—we hope—internal peace and controlled economies and strives, somewhat less successfully, to rout out crime, strife, and depression.

Science as Monoculture

Nevertheless there are limits to our husbandry in the field, in the laboratory, and in the legislature. We plow up the Great Plains and they blow away; we push agriculture too far into the forests and we create a precarious ecosystem. Agriculture, science, and government all result in a loss of species: An Iowa cornfield has far fewer species than the prairie which it supplanted.

Science is a world monoculture. The mandala of the periodic table appears in chemistry lecture rooms in Peking, Moscow, Rome, Tokyo, Hobart, and Singapore. There is no such thing as Communist chemistry, Catholic chemistry, or Hindu chemistry, white chemistry or black chemistry. Even economics is practiced somewhat furtively in the mathematics departments of socialist universities and Darwinian biology in the laboratories of Catholic universities.

Government likewise tends to create cultural uniformity, at least enough to ensure that everybody pays taxes. Only the nation, the religious sect, and the hippie cult stand between us and world monoculture.

There is something a little frightening in this. If one ecosystem goes wrong in a world of many ecosystems, the others do not; in a world of many isolated cultures, one can collapse, like the Mayan, and the others are quite unaffected. But if the world becomes a single ecosystem with a single culture, then if anything goes wrong, everything goes wrong. The Irish potato famine of the 1840s stands as a solemn record of the dangers of monoculture.

But as great as was the Irish catastrophe, it was retrievable because it was local. There comes a point as catastrophe moves toward universality where it becomes irretrievable. In a period of time over which the generalized Murphy's Law holds (if anything can go wrong, it eventually will), there is clearly an optimum degree of diversity from the point of view of maximizing the possibilities of continued long-range evolution.

"A Dynamic Dance of the Mind"

For those who live out on the great plains of science, where the rich square fields produce increasing yields under the benign inputs of advancing knowledge, it is easy to forget that the plains do not go on forever. The scientist who has never darkened the door of a church, who has never read Gerard Manley Hopkins, or St. John of the Cross, or George Fox, or even Tennyson's "In Memoriam," may be living in a more restricted ecosystem than he thinks. There is a dramatic moment as one drives across the Great Plains where the Rockies first rise above the endless horizon. Even if one never experiences this moment of exhaltation and lives in the middle of Kansas all one's life, it may be nice to know that the Rockies are there. Even if one spends one's whole life raising good, solid, sustaining, scientific wheat, it may be good to know that the fields end somewhere.

At the margins, life can be difficult as well as exciting. There is a constant tension between the urge to go off into the plains and raise solid and nourishing scientific wheat and the contrary urge to disappear into the great gothic forests of the mind and indulge shamelessly in prayer and praise, or even to climb to the icy summits of mystical union. To have a foot in each world can lead to a very uncomfortable straddle, but it does surely lead to a dynamic dance of the mind which is seldom enjoyed by those whose feet are solidly planted in the rich plains. These margins are a good place to live for those who are agile enough to survive in them, and it is necessary for some people to live in them if we are to see the great habitats of the human mind as a totality and not as a set of totally unrelated parts.

Kenneth E. Boulding, former President of the American Economic Association, is Professor of Economics at the University of Colorado and Director of the Program on General, Social, and Economic Dynamics at the University's Institute of Behavioral Science.

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Science Comes to Medicine—Slowly

Washington Report
by
Victor Cohn

In Washington, everything is political. This includes disease.

When Richard Nixon planned a 1972 campaign role for his daughters, he told his man Haldeman to have them go out to the "Middle America type of people" and "do the breast cancer thing." He wanted them to speak of his role in pushing a federal anti-cancer crusade, (once he was forced into it by Senator Kennedy and others).

When Mrs. Betty Ford had breast cancer surgery at the Bethesda Naval Medical Center on September 28, and the extent of the cancer's spread showed that her chance for long survival was uncertain, the question on political lips was, "Will this change the President's decision to run in 1976?" (He soon said it would not.)

When, within weeks, the wife of Mr. Ford's vice president-designate also developed breast cancer, one of the first reactions was a degree of sympathy for the increasingly beleaguered Nelson Rockefeller. Now he was not just Rockefeller, the political warrier, millionaire dynast and greatest of gift-givers. He was also Happy's loving husband whose main thought was her future.

Because Mrs. Ford and Mrs. Rockefeller and their husbands were all political persons at the very top level of American awareness, these women's breast cancers—like Nixon's phlebitis and Johnson's heart and Eisenhower's gut—were important news.

Furthermore, anything pertaining to this disease now became news. As it happened, there *were* in these same weeks some important new things to report. The entire country thus got a series of remarkable lessons in breast cancer prevalence, alternative kinds of breast cancer surgery and, in the process, science and even the ethics of science.

Still Waiting for the Wedding

There were not yet final answers. Much about breast cancer remains controversial or unsettled among medical practitioners. Much of the reason for this unsettled state—it became clear in those weeks of September and October—was medicine's long-standing failure to apply some of the simplest tests of science to this most common of women's malignancies and perhaps most feared of all cancers.

The breast cancer story has implications for many kinds of science and applied science.

In 1891, when Dr. William Halsted first removed a woman's breast at Johns Hopkins University, by what would soon become known as the "Halsted radical" operation, there had not yet been any real wedding between surgery and science. Each surgeon mainly did what he thought best.

If enough patients survived the very onslaught of the knife, the surgeon might write up his results. If the results seemed good enough, other surgeons might copy him. Not until the early years of the century did doctors like the Mayo brothers begin to look back systematically and assess their results, then guide their future operations by their past outcomes.

And not until the 1920s did more advanced biometrics begin to take hold in even the leading medical centers, with statisticians beginning to apply more sophisticated tests than just looking backward and counting.

One of the new biostatisticians' conclusions was that looking back—in statistical language, doing a retrospective study—is often unreliable. For many purposes, selecting a proper study population, giving alternate treatments on a randomized basis, *then* looking at the results—in short, making a prospective study—is far superior.

Starting 80 Years Too Late

Back to the breast. In the United States alone, 90,000 women develop such cancers and have such surgery every year. One woman in 15 can expect to get the disease sometime.

Yet not until three years ago was a group of academic surgeons headed by Dr. Bernard Fisher at the University of Pittsburgh able to begin what they and National Cancer Institute statisticians considered a properly designed prospective study of the true efficacy of Dr. Halsted's 1891 operation, compared with a simpler and gentler procedure.

Why so long a wait? Surgeons, says Dr. Fisher, are conservative types. Some operate all their lives in the way *they* were trained.

Not until the year 1971 could Dr. Fisher find surgeons at 34 centers willing to concede that they did not *know* which kinds of breast operations were better, therefore willing to compare the highly mutilating Halsted radical (which removes the breast, underlying chest muscles and the nearby armpit's complex of lymph nodes, the common site of the first spread of the disease) with two other methods—a so-called "simple" mastectomy (removing only the breast and no other structures) and a simple mastectomy followed by post-operative radiation.

Between 1971 and 1974 Dr. Fisher and his colleagues (in somewhat over-simple language) found that the results of 1,684 operations seem to show—there can be no certainty without longer follow-up—that:

—For cancers still limited to the breast alone, the simpler operation with or without radiation has the same results as the Halsted.

—For cancers with spread to the lymph nodes, the simpler operation with radiation has the same results as the Halsted.

On Saturday, September 28, three days before Dr. Fisher was to present these findings at the National Institutes of Health, just across the avenue from the Naval Medical Center, Mrs. Ford's surgeons, though knowing of Dr. Fisher's results, chose to perform on Mrs. Ford (whose cancer, remember, had indeed spread) a full Halsted radical mastectomy A few weeks later Memorial Sloan-Kettering surgeons chose to perform on Mrs. Rockefeller (whose cancer, so far as could be determined, had not spread) a "modified" radical, which leaves some of the muscles.

In both cases, the surgeons said that *their* and *others'* past results showed superior survival rates for the more extensive surgery. Dr. Fisher did not directly comment, except to say it was too bad that the more scientific study had not started years earlier, so the answers would now be more certain.

One wonders how many other surgical procedures are equally uncertain, and how many future patients might benefit from more science in surgery.

Ironically, Dr. Fisher—the man who felt so strongly about investigating the possibility of a gentler breast operation—during most of the time of his study used a consent form which did not inform each patient that:

—*Most* surgeons, though not the academic group, still believed that more radical surgery was almost always advised;

—*Her* own treatment would be chosen randomly, from a number list spewed up by a computer.

Dr. Fisher strongly (and probably correctly) maintained that he had taken great

pains to explain all this to each patient *orally*. But one of Washington's more important public interest law firms, the Center for Law and Social Policy, said his consent form over-rode any oral explanation, even if there were such an explanation, well-understood. N.I.H. in effect agreed by virtually ordering Dr. Fisher and other participating surgeons to improve their consent procedures for this and future studies.

"We're in a new day for medical ethics," one N.I.H. official said. "No one would have criticized Bernie Fisher's consent forms a few years ago. Now we have to make much surer that the patient is making a conscious choice to take part in an experiment."

Will such candor make it hard, or impossible, to get patients to take part in future medical experiments?

Only time will tell, but I don't think so. I interviewed three patients who had not only been given Dr. Fisher's oral explanation—and, according to them, he had talked to them for up to an hour and a half—but *also* had seen and signed his new, very complete written explanation.

Still, some weeks after the event, only two of the three had any clear idea that their operation was being selected at random.

At first surprised that only one of the three really knew what she had signed, Dr. Fisher on reflection said: "I think it's remarkable that any of these patients remember, because they suppress the information you give them."

As who might not?

There has long been a Walter Reed Society for medical scientists who expose themselves to their own experiments. It might be nice if someone struck some similar medals or certificates for these women and others who, informed or not, take part in experiments to benefit others. By their very nature, they are experiments which almost no lay person can ever fully understand.

Victor Cohn, formerly its Science Editor, now reports on major science-oriented affairs for The Washington Post.

Banning DDT: An Ill-Planned Biogeochemical Experiment

Environment/Technology
by
Ian C. T. Nisbet

After years of debate and controversy, we have at last started to restrict the release of persistent, toxic chlorinated hydrocarbons into the North American environment.

The first decisive action was taken in September, 1970, when the manufacturers of polychlorinated biphenyls (PCBs), then widely used in industry, voluntarily withdrew them from sale for most of their dispersive uses. This was followed in 1973 by a still more unusual action, an agreement by the countries of O.E.C.D. on a uniform policy to restrict uses of PCBs. There is a remarkable contrast between the willingness of the chemical industry to accept these unprecedented restrictions on an industrial chemical, and the vigorous opposition by the same industry to restrictions on the chlorinated hydrocarbon pesticides, whose toxic hazards are much more clearly established and whose economic benefits are now much more questionable.

The first general restriction on a persistent pesticide did not take place until June, 1972, when most U.S. registrations of DDT—and of the related insecticide TDE—were cancelled by the Environmental Protection Agency after a lengthy hearing. This was followed in October, 1974, by an emergency order suspending production and most uses of the insecticides aldrin and dieldrin. The E.P.A. is now conducting hearings with a view to cancelling registrations of Mirex and is reviewing evidence on the hazards of heptachlor and chlordane. Restrictions on other persistent insecticides, including BHC, lindane, hexachlorobenzene, endrin, and thiodan, are expected to follow as the regulatory machine grinds on.

The reasons for imposing restrictions on the insecticides were broadly similar in each case: their long life in the environment (either in the form of the parent chemical or as persistent metabolites); their mobility and tendency to accumulate in plants and animals; their widespread occurrence in human food and human tissues; and their broad biological activity—in particular, the ability of several to induce cancer in experimental animals, judged by cancer experts to indicate a cancer hazard to man. Not least, several of these pesticides have been declining in effectiveness as the target insects develop resistance to them, and they are therefore replaceable for most of their uses at little or no net additional cost.

Nevertheless, the sweeping nature of the E.P.A. restrictions has been widely criticized by manufacturers and users, who argue that some uses lead to negligible contamination of the environment. Although few if any cancer experts accept the concept of a "threshold dose" for a chemical carcinogen—a dose below which the probability of response is exactly zero—there must be some exposure level below which the hazard to a population becomes extremely small. Surely—the argument runs—there are uses for these chemicals that are so minor or in which the insecticides are so well contained that they lead to a risk low enough to be acceptable. Or perhaps there are some uses so strongly beneficial that society should accept a finite risk. How are we to make this determination?

The first point to note in considering this question is that some such determinations have already been made, for none of the restrictions constitutes a complete ban. DDT, for example, has never been banned for public health purposes in the United States, and in addition it has been granted several special registrations since 1972 for uses which include applications to coniferous forests and peafields in the northwestern states. PCBs are still used in large transformers and capacitors and as hydraulic and compressor fluids. Aldrin and dieldrin are still permitted for uses underground to combat termites, for dipping nursery plants, and for mothproofing carpets. The decisions to permit these uses (and to refuse others) represent a balancing of risks against benefits. How are we to judge whether this balancing has been well carried out, or is too stringent or too lax?

An Enormous Problem in Biogeochemistry

Although estimating the benefits accruing from specific uses of a chemical is often difficult enough, perhaps the most difficult aspect of this problem is calculating the relationship between use and subsequent exposure. When 300,000 kg. of DDT is sprayed over the forests of the Pacific Northwest, where does it go? How much is transported away? How much is taken up by plants and animals? How much appears in human food? When, where, and by whom is it consumed? We must answer similar questions in respect of every proposed use that would result in release into the environment. What happens, for example, when a transformer containing PCBs catches fire? What are the ultimate consequences of the use of 500 kg. of dieldrin each year on the cranberry bogs of Massachusetts?

In essence, we are faced with an enormous problem in biogeochemistry: to trace or predict the entire process of transport and transformation of a chemical, from its initial release into the environment to its ultimate degradation or sequestration. If we regard the environment as a huge "black box," we have to predict the exact relationship between the specific inputs that are under consideration and certain critical outputs—primarily those into human foods. To guide us, our primary source of information lies in past measurements of inputs and outputs; for the chlorinated hydrocarbons, these measurements are seriously incomplete. Despite extensive monitoring, some of the most important outputs for these chemicals—such as transfer to the deep oceans and photochemical degradation—have never been measured satisfactorily. Even the patterns of use and release into the environment for many of these chemicals have not been recorded fully: Most of the chemicals have been used for many different purposes, and some minor uses or methods of disposal have never been reported or recorded.

In recent years several models have been constructed to describe the environmental transport and distribution of the chlorinated hydrocarbons. Most of these models, however, have been highly aggregated and merely relate global patterns of use to average levels of contamination. Attempts to model regional or local patterns of distribution have been less satisfactory. When we break open the "black box" and attempt to elucidate the critical mechanisms within it, we find that it is dauntingly complex. As I will show in my next article, we are not yet able to specify with certainty the critical pathways of transport or transformation for any of these chemicals.

A Lost Experimental Opportunity

One of the principal difficulties is that the outputs with which we are most concerned—those leading to human exposure—represent very minor mass flows. For example, total usage of aldrin and dieldrin in the U.S. has recently been running at 4 to 5 million kg. per year. Yet monitoring of human food suggests that the total amount of dieldrin ingested by

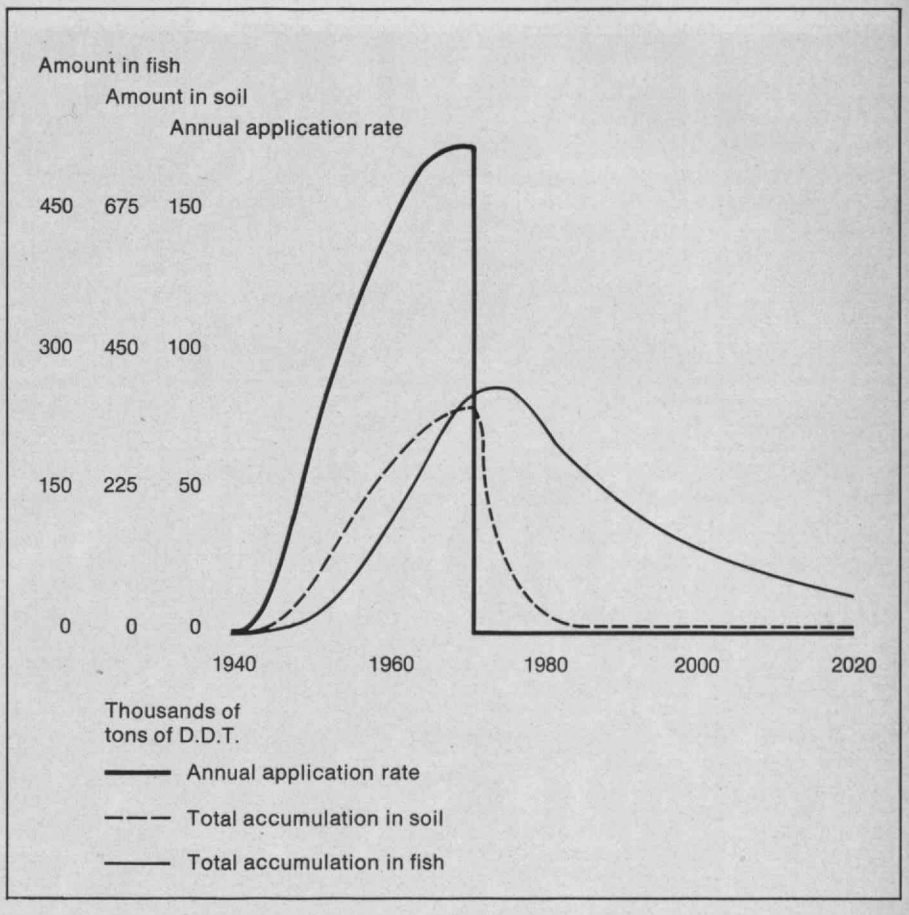
the U.S. population of 210 million persons is only a few hundred grams per day. Clearly a very minor route of release into the environment has the potential of becoming a major route of human exposure.

There is in fact some evidence that some minor uses have indeed been important sources of human intake. Most human exposure to PCBs, for example, appears to be through fish in the diet; much of the residues in fish can probably be traced to leakage and disposal of spent hydraulic fluids into waterways. Studies in Europe have suggested that the use of dieldrin in sheep dips was a disproportionately important source of residues in human food, both because of direct uptake into the fat of the sheep and because the used material was often discharged into rivers and taken up by fish. Likewise the use of DDT and other pesticides on tobacco is believed to have led to important human intakes through tobacco smoke. These examples show that even low volume uses cannot be assumed to be insignificant.

An additional complication is that none of these problems involves only one chemical. Aldrin, for example, is converted in the environment into dieldrin, which is more persistent, more soluble in water, but less volatile than aldrin. DDT is similarly transformed into DDE, which is more volatile, more persistent, and has more serious biological effects than the parent compound. PCBs are mixtures of dozens of different chemicals with marked differences in mobility, stability, and biological activity. Environmental transport models which treat these mixtures as single substances—as most existing models do—may thus be seriously misleading.

In one sense, the banning of DDT/DDE and aldrin/dieldrin could be regarded as a vast biogeochemical experiment, the culmination of 25 years of shifting uses. If we had organized our existing knowledge of these chemicals to formulate comprehensive environmental models, we could now be utilizing the abrupt cessation of imputs to measure local rates of decay, transfer coefficients between phases, and ultimately rates of dissipation. Such information could not only have helped to resolve our uncertainties in interpreting past events in North America and Europe; it could also have helped to define the degree of hazard associated with the continuing uses of these chemicals in other parts of the world.

Unfortunately, the opportunities are being lost because—as I will show next month—the critical measurements are not being made. Unless they are, some of the key questions about these chemicals may never be answered. In particular, there can be no sound basis on which to rest a conclusion that the minor uses of DDT, PCBs, and dieldrin that are still permitted do not lead to significant contamination. Until we are able to make sounder predictions, simple prudence requires that we should be over-conservative in regulating the use of these uncontrollable chemicals.



This analysis, made by Jorgen Randers while he was a graduate student at M.I.T., shows the amounts of DDT that would remain in the environment had a complete, world-wide ban on its use been effective at the end of 1971. In practice, only a few countries have restricted the use of DDT to date, and the observed effects have been more complicated. Residues of DDT and DDE have declined fairly rapidly in some open coastal eco-systems but less so in human food and not at all in some inland waters. In Sweden, levels of DDT have fallen markedly in human food, but levels of DDE have remained constant. More elaborate models are needed to account for and predict these phenomena. (Chart: Jorgen Randers in Toward Global Equilibrium: Collected Papers, *ed. by Donella H. Meadows; Cambridge: Wright-Allen Press, 1973)*

Ian C. T. Nisbet, who writes regularly for Technology Review, *is a member of the Scientific Staff of Massachusetts Audubon Society. His Ph.D. (in physics) is from Cambridge University.*

World population is growing faster than world food resources, and a "food crisis" may soon follow the pattern of the "energy crisis." Though the issues are large and the problems immense, science and engineering hold important keys to increasing supply and reducing demand

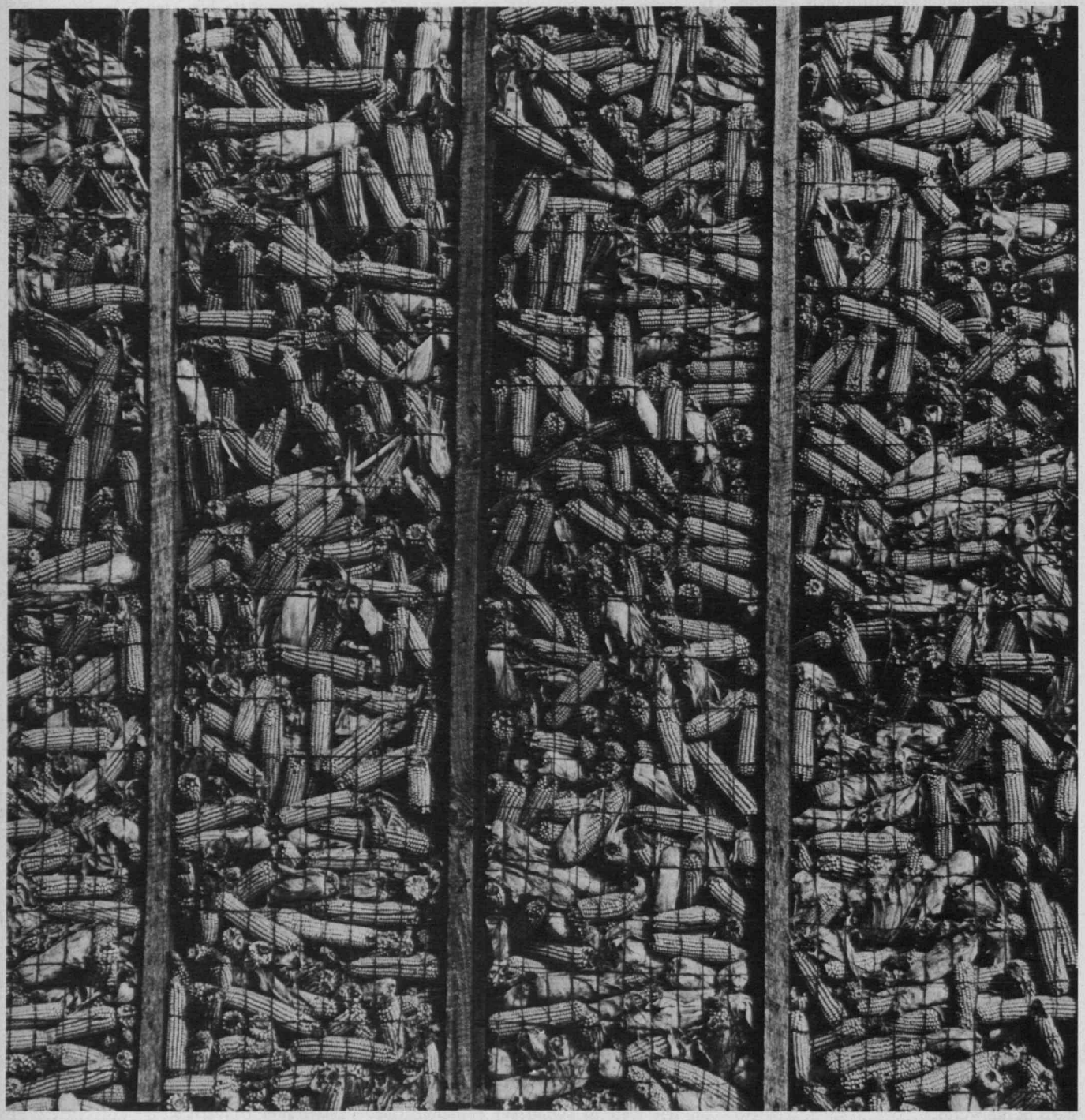


Photo: Anna Kaufman Moon from Stock, Boston

Dr. Nevin S. Scrimshaw
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The World-Wide Confrontation of Population and Food Supply

There has been ample warning of impending food problems, but until rising demand and poor crops in several major areas of the world resulted in the disappearance of U.S. food surpluses, and the energy crisis raised the price and reduced the availability of fuel and fertilizer needed for improving agricultural production, these warnings were largely unheeded.

Now evidence is rapidly accumulating to show the approach of one of those crisis points in history when new elements will force a fundamental discontinuity in the way the twin problems of people and food supply are handled. Simply put, the world cannot long continue with the kinds of trends currently seen in population, land availability, food production, energy use, environmental pollution, and inflation. It is apparent that world food needs are increasing rapidly and will continue to increase rapidly for at least the rest of the century—1.4 billion more persons to feed between 1950 and 1974 alone. The population of the earth has already doubled since 1940 with the addition of two billion people, but today's numbers will double again within the professional lifetime of many readers.

For most countries of the world, domestic food production has failed to keep up with this increase. Before 1940, only Europe was a net importer of food. Now not only Europe, but also Asia, Latin America, and Africa must import increasing amounts of food, most of which comes from North America, where there has been a phenomenal increase in exports—from five million metric tons in 1940 to 91 million tons of grain alone last year. Australia, with about 6 million tons exported last year, is the only other important source. Thus, the world has become dependent on North American food exports, mainly of cereal grains and soy beans.

The effect of rising affluence is another major pressure on world food needs in addition to population growth. Asians and Indians, whose diet consists mainly of rice or wheat, eat about 400 pounds of grain per person per year, but a North American now uses nearly 2,000 pounds of grain, even though he consumes directly only about 140 pounds. The rest is consumed indirectly as meat, milk, and eggs. For example, annual beef consumption in the United States has grown from 55 pounds per person per year in 1940 to 117 in 1972. The conversion ratio is eight pounds of grain to produce one pound of feed-lot beef. The growth of beef consumption, combined with a 57 per cent population increase since 1940, has made the U.S. a disproportionate grain consumer and a major beef importer. The increase in poultry consumption has been even greater, although the conversion ratio is more favorable. Part of the world food problem is that the populations of Europe, Japan, and growing minorities in all countries are following the pattern of higher animal protein use and thus are increasing the world demand for grain and protein concentrates for animal feeding far beyond that accounted for by population increase alone.

How Far to Stretch the Limits on Supply?

As long as the U.S. had ample grain stores and was liberal in its concessional sales and donations to the poorer countries, the impending food crisis was largely ignored. In the late 1960s and early 1970s, it appeared that the introduction of new varieties of cereal grains, along with fertilizers and pesticides, could bring the Green Revolution to developing countries which would help them meet their food needs for years to come. Indeed, marked increases in the yields of the new rice varieties in many Asian countries and of wheat in the Indian subcontinent *did* stave off disaster. The Green Revolution techniques still have much to contribute to the developing world and should be vigorously encouraged and promoted.

But the limitations to the Green Revolution have gradually become apparent. In countries that initially benefited greatly from it, the lack of additional land with sufficient available water and the current fertilizer/energy crisis have, temporarily at least, brought the Green Revolution almost to a standstill.

The problem has been exacerbated by other events. In the summer and fall of 1972, dry weather in the Soviet Union, Argentina, Australia, and many other countries cut sharply into grain production and led to greatly increased purchases from North America. The result was that the food stockpiles that had seen the world through many local and regional crises over recent decades virtually disappeared. At the same time, the anchovies off the coast of Peru, a major protein source for animal feeds, especially for Japan and Europe, became scarce because of a shift in the Humboldt current and over-fishing. The only available protein substitute for use in animal feed was U.S. soy beans. Prices soared for both cereals and soy bean meal, and meat prices followed. Simultaneously, world fisheries surpassed maximum sustainable yields for many species and began a decline.

In 1973, greatly increased acreage was planted in the United States, but because of planting delays

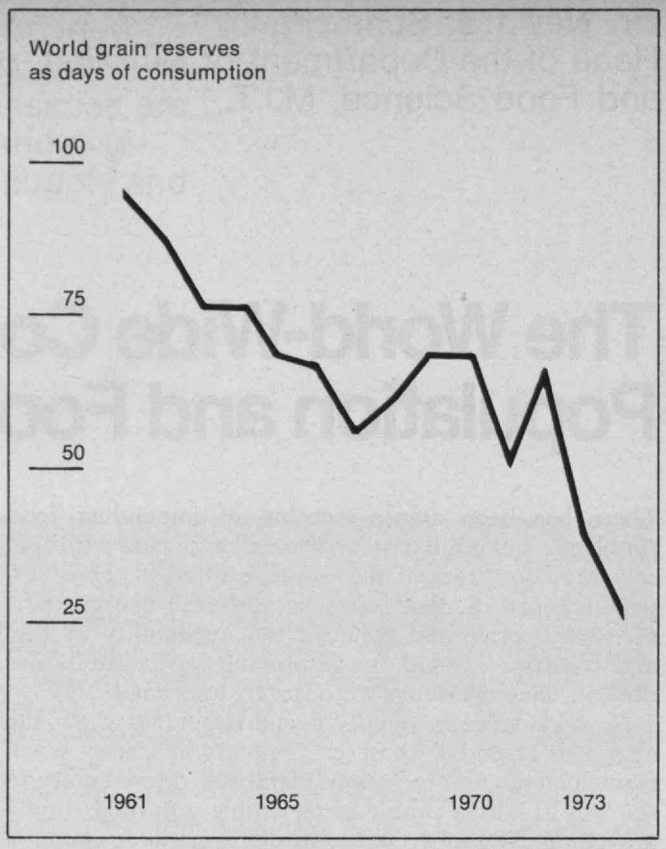
caused by unusually wet weather, grain and soy and hence meat prices rose further. For a time, export controls were placed on soy beans, much to the dismay of countries that had been assured that they could depend on U.S. exports of this commodity. The continuing drought in the African countries below the Sahara brought much suffering and publicity and need for emergency food shipments, but the steadily worsening food situation, which included India, Bangladesh, Pakistan, and Indonesia with their huge populations, was not as well understood.

In the United States, all limitations on planting agricultural land were removed during 1973, so that now there is no longer significant agricultural land in reserve. A bumper crop was predicted for this year. But now, because of moderate drought in the middle western United States this past summer and early frosts this fall, estimates of the 1974 corn and soy bean crops are down sharply and the record wheat crop is, unfortunately, less than predicted or needed. Prices of these commodities have risen further.

Latest projections show the prospective world wheat crop this year to be about 9 million tons less than predicted only a month ago and approximately 16 million tons *less* than last year, mainly because of drought in previous grain-producing areas and frost threatening late-maturing crops in Canada. In the meantime, India is said to need 8 to 9 million tons of wheat to stave off massive starvation in its drought-stricken areas, a crisis that promises to be worse than in 1967 when the United States supplied India with massive wheat shipments from its then-abundant surpluses.

How will the world manage if a drought next year is worse? Indeed, with the world so dependent on North American food exports, many are deeply concerned about the consequences of a series of dry years. Such an event caused the "dust bowl" of the 1930s and the lesser drop in food production in the 1950s. Such dry periods have occurred irregularly, but with an approximate 20-year periodicity, for as far back as tree-ring data are available. There can be no long-range substitute for increased food production in the developing countries through higher yields and less reliance on North America, but no one believes that this will be easily or rapidly achieved, and it will require far more assistance from the industrialized countries than has thus far been forthcoming.

Last winter, the long-pending energy crisis emerged to greatly inconvenience the industrialized countries.

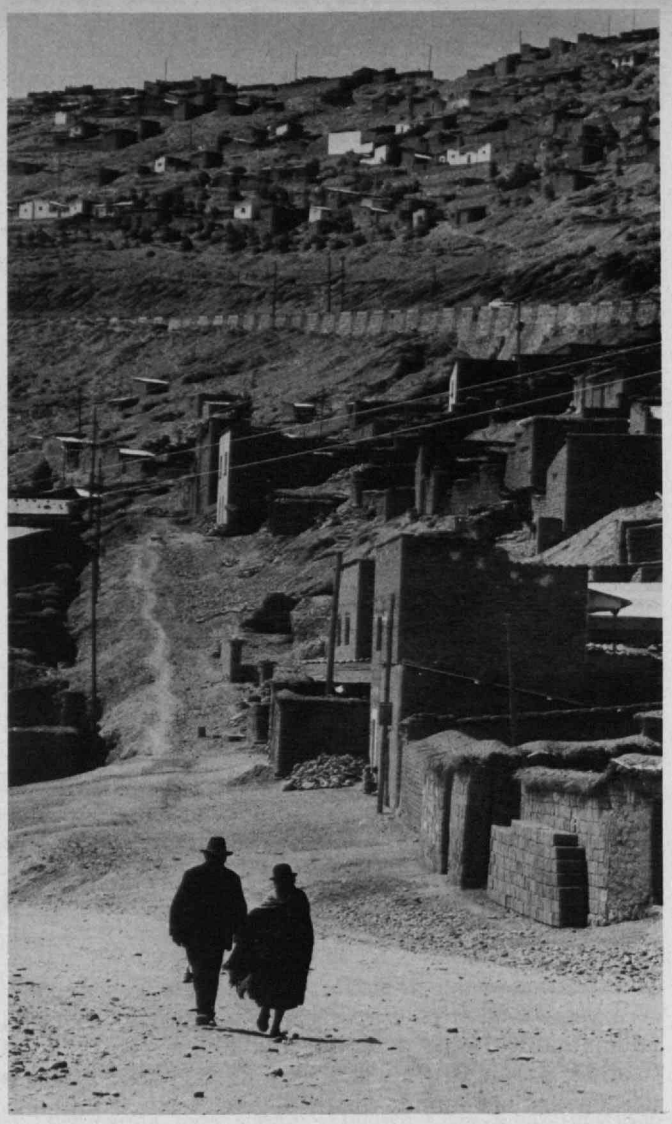


In the past three decades the world has had two principal reserves of food—the stocks of surplus grain held in the principal agricultural nations, and the rich croplands held out of production in the U.S. under government farm programs. The farm programs designed to maintain farm income by reducing surpluses have almost without exception ended; and growing population and affluence have brought increasing food demand in the U.S. and throughout the world. In 1961 the two reserves represented 222 million tons of grain, according to Lester R. Brown and Erik P. Eckholm of the Overseas Development Council; today the reserves are just over 60 million tons. (Data: Overseas Development Council from the *New York Times*)

But for many developing countries, the effects were disastrous. For example, India lost one million tons from her spring crops, largely because of lack of fuel for pumping irrigation water, and probably 10 million tons from her summer crops. The summer losses occurred because of lack of fuel and fertilizer; India could not afford to buy them in the quantities needed, and for a time supplies were simply not available on the world market. Sufficient central food reserves to provide for drought-stricken regions are simply non-existent in India today.

Bangladesh, which was already importing nearly two million tons of grain for distribution through rationing to nearly 20 million people—over a quarter of its population—found its costs for food, fertilizer, and fuel nearly tripled and far exceeding its available foreign exchange. In August of this year, two-thirds of the country was flooded and part of the rice crop was lost; the government was required to feed, temporarily at least, an additional five million people. Unless Bangladesh is given additional grain to continue to meet much of this need, many of her people must starve.

World food reserves have now dropped to less than a 30-day supply, and the United States and Canada no longer have substantial reserve food stocks to respond to world emergencies.



How many people the earth can support depends on climate, and in some subtle way climate depends on the earth's human burden. Year-to-year variations superimposed on such broad changes are more spectacular if no more predictable; the only insurance, says Professor Helmut E. Landsberg of the University of Maryland, "is to have an adequate reserve on hand to compensate for the inevitable occasional crop losses." (Photo: Nicholas Sapieha from Stock, Boston)

Shortage and Its Human Consequences

Of course, by eating less animal protein and consuming more protein of vegetable origin, affluent countries could release large amounts of grain and soy for direct human feeding. The temporary withholding of fertilizer from golf courses would alone go far toward meeting the immediate needs of developing countries. Will we continue to respond to the needs of starving people, or will we simply become increasingly callous toward hunger and starvation in many of the developing countries? There is some evidence that many political leaders in both developing and industrialized countries are becoming fatalistic and trying to ignore a problem that has become too overwhelming for them to contemplate or solve.

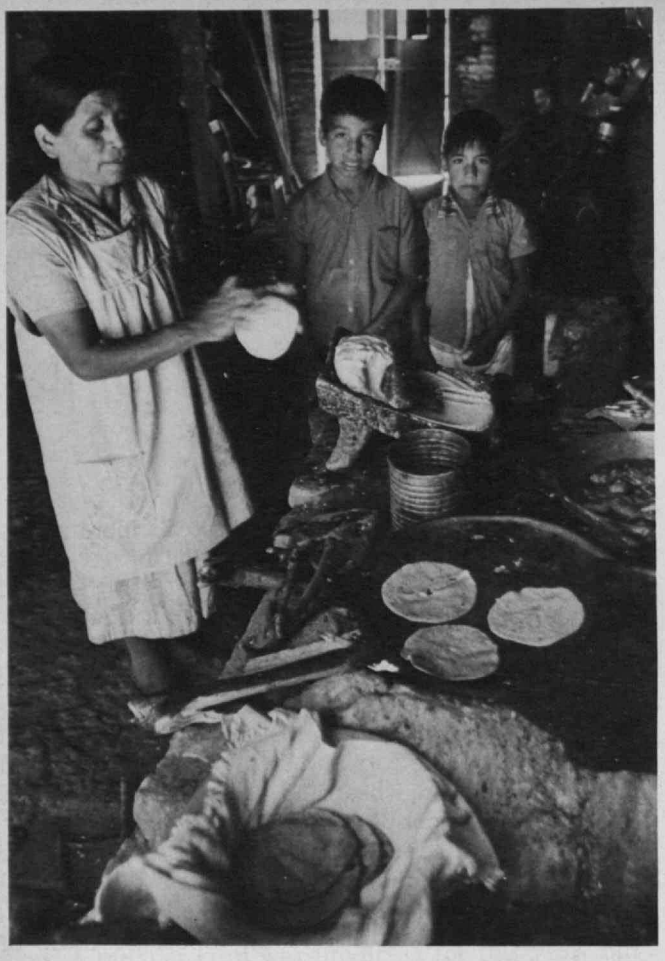
The situation is worsened by the fact that the pressure to produce not only cereal grains in order for adults to have food on which to survive and work, but also yield improvements that make cereals more profitable to grow, have resulted in a decline in per capita legume production in most developing countries and even an absolute decrease in some. Yet for young children, pregnant and nursing mothers, and persons experiencing stress associated with disease and trauma, predominantly cereal diets are made adequate in protein only by the consumption of legumes. The rice and soy diets of Asia, the corn and bean diets of Mexico and Latin America, and wheat and chickpea combinations of the Indian subcontinent are examples.

As legume prices are forced up by shortages, the quality of diets for the poor deteriorates. While world per capita protein supplies are still adequate, the maldistribution of protein-rich foods, especially those of animal origin, among countries, among socioeconomic groups within countries, and among families makes the protein problem a serious one. The dietary factor most responsible for kwashiorkor, the severe form of protein malnutrition, is the failure of the preschool child to receive a proportionate share of protein sources in an already limited family diet.

The human consequences of all of these factors are discouraging to contemplate. In many developing countries, food prices have sometimes doubled or tripled for a family already spending 80 per cent of its income on food, without any increase in wages. This can only mean hunger and malnutrition—for some, slow starvation. Severe cases of malnutrition are increasing in frequency, and mortality rates that had been falling steadily in recent decades have, since the first of the year, begun to rise again, according to reliable reports from such diverse countries as Guatemala, Barbados, India, Bangladesh, and Thailand.

Hunger breeds malnutrition, and malnutrition breeds on itself. The working capacity of adults is curtailed by caloric deficits. In Bangladesh, many families are eating only every other day because there simply is no more food available to them. Rising malnutrition impairs the efforts of less developed countries to grow more food and to cope with their population and development problems.

For example, experience shows that family planning is not acceptable where infant and child mortality rates are high because parents feel they must assure themselves of surviving children. Good nutrition of mother and child is the main factor in child survival. Moreover, educational and development efforts in developing countries are hindered when children—future leaders



It is no accident that the traditional diets of many peoples are built around vegetable—instead of animal—proteins. The latter are not essential from a nutritional point of view, and the author calls on food technologists "to devise more attractive ways of using the protein from soy beans, peanuts, cottonseed, sesame, sunflower, rapeseed, coconut, and the like in accord with the diet patterns and preferences of the individual populations to whom these oilseeds are available." (Photo: Peter Menzel from Stock, Boston)

and citizens—whose physical growth and development are retarded also show poorer mental development, learning, and behavior. This is mainly due to the fact that listless, apathetic children experience less interaction with adults and their environment and, therefore, less stimulus to the normal development of their central nervous systems. Such children also have smaller brains, with fewer nerve cells, but this may not be of functional significance *per se*.

It must be concluded on the basis of these facts that the prospects for underprivileged families and underdeveloped countries of breaking the vicious cycle of poverty, malnutrition, and ill health, are worsening rather than improving, and the world is sinking further into a morass of its own making—one from which it still can extricate itself only by effective leadership, action, and international cooperation to alter those trends leading to disaster.

Science and Technology vs. Famine?

In this new kind of world, what is the role of the scientist and engineer? Clearly, the final solutions depend on limiting population growth and increasing agricultural productivity in the developing countries. In these tasks, and in meeting intermediate food and nutritional needs, food scientists and technologists can contribute more importantly than ever before.

First, the post-harvest losses of food to insects, rodents, molds, and simple spoilage are needlessly high in all countries and may be as large as 50 per cent in those very developing countries that are having the hardest time feeding their populations and that can least afford *any* preventable loss. Moreover, deterioration in nutritional quality is second only to the quantitative loss. Improvements in storage, processing, packaging, and distribution are all required.

In addition, there are many processing by-products of high potential nutritional value that are now lost to human consumption. While some of these are at least used for animal feeding, others—such as cheese and soy bean whey—are largely contributing to environmental pollution. This waste must stop, and scientists and engineers must continue work on the recovery of edible products from various agro-industrial wastes.

It is also a waste of grain to use it as feed for beef cattle before slaughter to increase the content of body fat; part will be trimmed and discarded and part will be eaten by those for whom it may lead to obesity and heart disease. The standards for beef should be redefined so as to encourage the production and use of leaner meat. Tenderness should not be a problem, because food technologists already have several effective ways of tenderizing meat less marbled with fat. Moreover, even without tenderizing, there are many good ways of cooking such meat, even in gourmet dishes.

Substitution of Vegetable for Animal Protein

We know that, from a purely nutritional point of view, animal protein is not essential, and large numbers of the world's people are already existing on diets that are largely and sometimes wholly vegetarian. It is unthinkable that world per capita meat consumption can rise to match to that of the affluent populations today, because of the multiplier effect on the demand for feed grains and for protein concentrates. On the contrary, it appears inevitable that textured vegetable proteins, giving much the satisfaction of eating meat, will become increasingly important as technological skill in their fabrication increases. In the United States, per capita beef consumption has already begun to decline, and the use of hamburger extenders and other vegetable protein substitutes is growing steadily.

It is now up to the food technologist to devise more attractive ways of using the protein from soy beans, peanuts, cottonseed, sesame, sunflower, rapeseed, coconut, and the like in accord with the diet patterns and preferences of the individual populations to whom these oilseeds are available. Not only must the extrusion technologies developed for texturizing soy protein be adapted to other protein sources; we must also build on such home processing techniques as the making of tempeh, ontjom (oncom), and tahu from soy and peanut, as in Indonesia, and the various methods common throughout Asia for making bean curds. The excellent technology for preparing soy milk for infant feeding is an example of what can be achieved, as is the development of Miltone, a milk incorporating peanut protein isolate, by the Central Food Technological Research Institute in Mysore, India. The textured mung bean

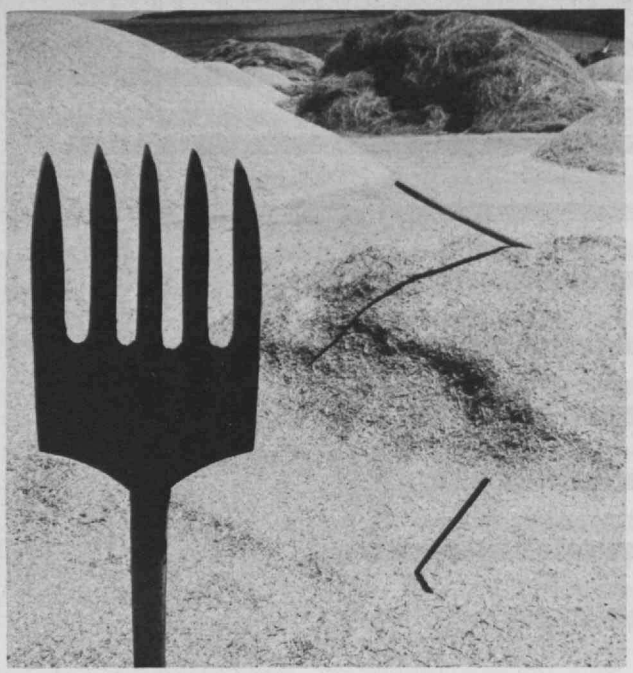


Photo: Harry Wilks from Stock, Boston

Four Imperatives Against Hunger

Lester Brown, vocal Senior Fellow of the Overseas Development Council, and Professor Glen L. Urban, a specialist in population and health planning at the Sloan School, met with Dr. Scrimshaw last spring at M.I.T. to discuss "Policy Responses to World Food Scarcity." They agreed that only vigorous, immediate action can reverse the trend of increasing world population and decreasing per capita food supply. Following are what they perceive to be four policy imperatives arising from the situation:

1. The full food-producing potential of the underdeveloped nations must be achieved with a large commitment of energy, technology, and resources. For example, India has under cultivation 350 million acres, almost exactly the same amount as the U.S.; but with a comparable soil and water potential, India's crop is two fifths that of the U.S. Fertilizer, technology and water make the difference.

2. An international food reserve is desperately needed. Present reserves of food are dangerously low, and the world has become too heavily dependent on regular food exports from North America. The U.S. and Canada are both affected by the same climatic cycles—by depending solely on them the world is in effect putting all its wheat in one basket.

A world food reserve can be created in one of two ways. An international agency patterned after the U.S. Commodity Credit Corp., for example, could handle the responsibility for acquiring commodities when prices dropped to a certain level, releasing them when prices rose. Alternatively, a series of individual national food reserves could be gathered with the sum of those reserves calculated to represent a sufficient world reserve to meet any emergency. This would avoid the issues of national sovereignty raised by the first alternative and would in the short run be politically more attractive. Such an international agency approach would have the advantage to the exporter of sharing with the importers, in effect, some of the cost of maintaining food reserves. Until now maintenance of reserves has been a service that only a small number of exporters have provided to importing countries.

3. Present patterns of excessive food and energy consumption by developed nations must be modified. Pressure to share scarce resources, as well as pressure to simplify diets, will be felt in the U.S. The average North American will no longer be able to use four to five times as much of the world food resource as the average citizen of a developing country. The easiest way to simplify diets would be to decrease the per capita consumption of red meat, and thus decrease the amount of inefficient livestock production and free land for other uses.

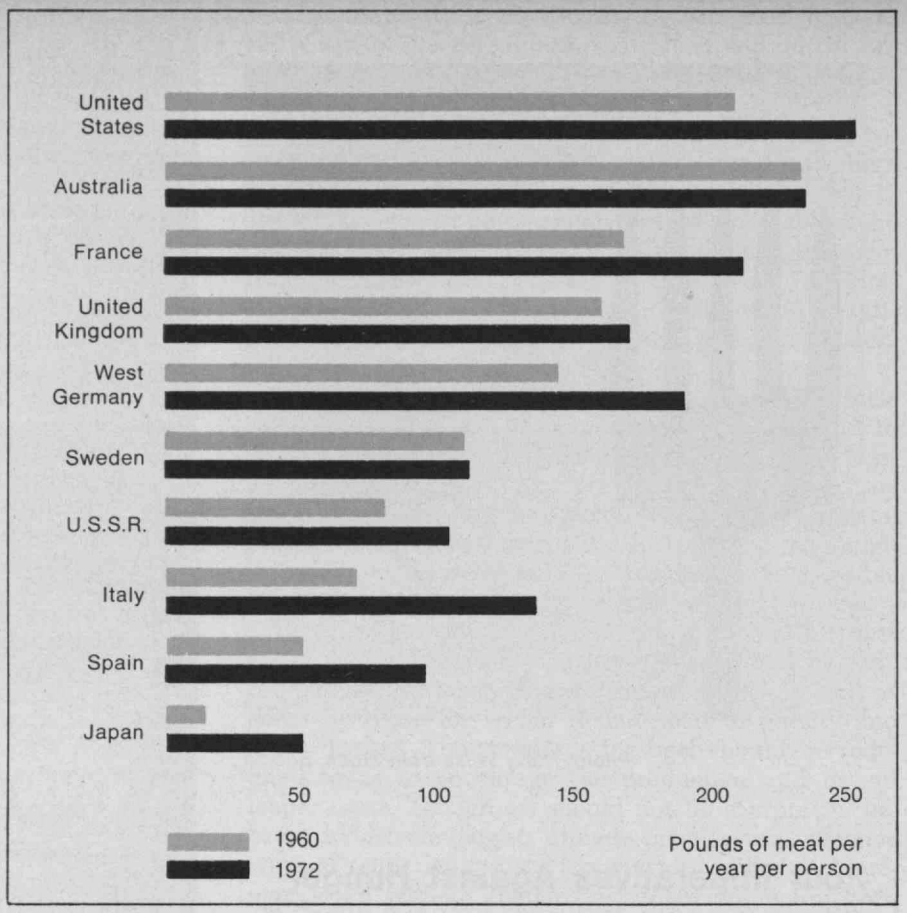
An interesting foreign policy question arises here: Will the industrial countries, with their large herds of livestock, be prepared to cut these herds back? It is not an impossibility. For balance-of-payment reasons, Argentina reduced beef consumption from 200 to 136 lbs. per capita last year. Italy has initiated meatless days. The U.K. has reduced its per capita beef consumption by 20 to 30 per cent in the last 15 years and has made a corresponding increase in consumption of poultry, a much more efficiently produced form of animal protein. High beef prices in 1973 caused U.S. beef consumption to drop four pounds per capita, the first decrease in 20 years. Indeed, there is evidence that diet simplifications may come more easily than has been anticipated.

4. The central, long-term issue is the curtailment of population growth rates. Governments in the developing world have realized the need for population programs, and some have been put into practice over the last 10 years. Currently about 75 per cent of the developing world's population has access to some organized family planning program. Access, however, does not guarantee success.

At the lowest level are facilitative programs, making contraceptives and factual information about birth control available. The low success of these programs has led some nations to the next level—the persuasive use of mass media publicizing the personal and national benefits of having fewer children. This method has also met with limited success. Incentive-based programs—in India, compensating men for vasectomies, in Taiwan, providing money for the education of children of a mother using contraceptives effectively—have been better received.

At least three major changes must take place at the level of global policy to result in the order of reduction that is required. First, the resources put into population control must be increased exponentially. The U.N. Fund for Population has reached an all time high in programming $70 million annually, but several hundreds of millions of dollars would be an investment more consistent with the magnitude of the task. Second, there must be new and more fruitful research in the technology of contraceptive mechanisms and fertility controls. Commitments equal to those typical in the U.S. to fight cancer and heart disease might make possible a technological breakthrough in this area. Third, we need to improve the management of family planning programs in the developing nations. In general it can be said that the programs are uncontrolled, that there are no aggressive plans and poor results. The management to transform these resources into action must be improved before financial and technological supports can be effectively applied.

The threat of world food shortages arises from growing world population compounded by growing world affluence—the latter represented, for example, in the rising consumption of meat in the industrial nations. Meat is a grossly inefficient form of food: beef cattle return in food only 5 per cent of the calories they consume in the years before slaughter, hogs and chickens about 10 percent. Lester Brown of the Overseas Development Council proposes that Americans could free 12 million tons of grain if they reduced by 10 per cent their meat consumption in 1975; that 12 million tons of grain would feed 60 million people. (Data: Organization for Economic Cooperation and Development and U.S. Department of Agriculture, from the *New York Times*)



protein, Kasetprotein, developed by the Institute of Food Research and Product Development of Kasetsart University in Bangkok, Thailand, is a good example of needed progress; the protein from the preparation of mung bean starch is an example of a valuable source now largely wasted.

The direct use of legumes such as the common bean, chickpea, cow pea, and pigeon pea for infant and child feeding is limited by processing knowledge.

The opportunities for developing weaning foods by using indigenous vegetable protein sources have been exploited in only a limited number of countries. Every developing country should have foods that can play the role milk plays in the industrialized countries after weaning, but at lower cost. The usefulness of Incaparina in Central America, Bal-Ahar in India, Superamine in Algeria, and a number of other such products clearly indicates the possibilities.

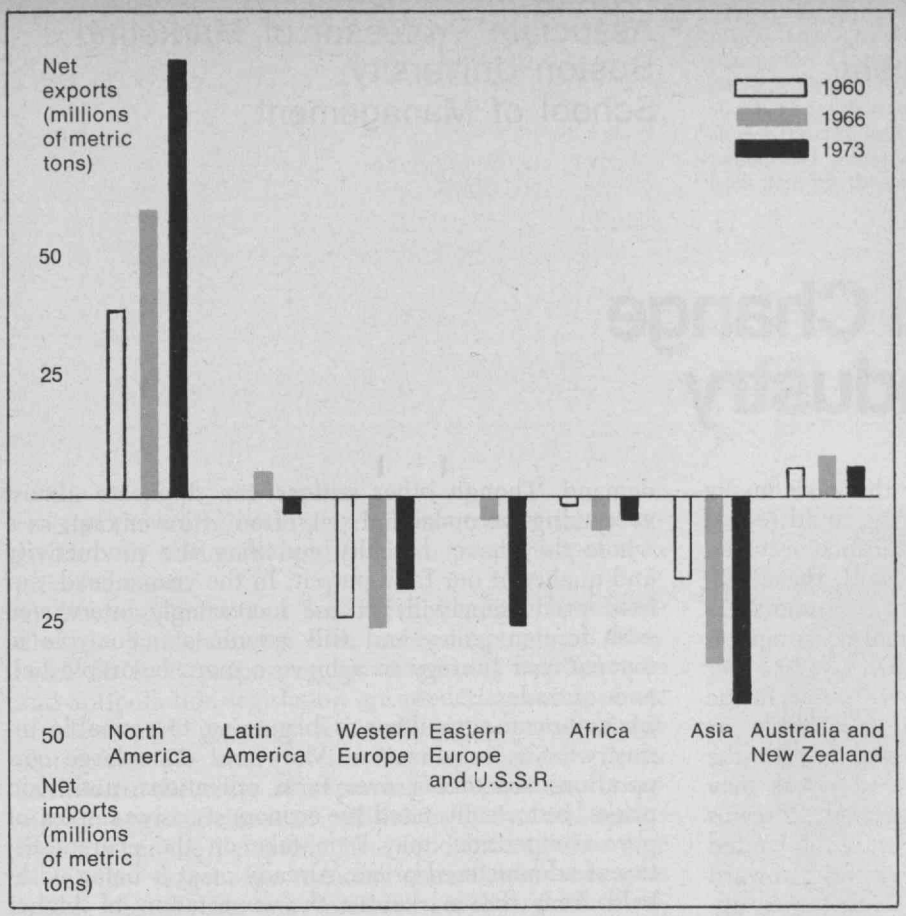
There is also a need for formulas using vegetable protein to lower the cost of infant feeding during the early months for low income mothers in the cities of developing countries, where they must wean their children early in order to work. While it would be preferable for them to continue breast feeding, at least during the first year of the infant's life, millions of mothers are now, for economic and social reasons, substituting grossly inadequate infant feeding regimens that contribute to the frequency of infantile marasmus.

Some of the processes for the utilization of agricultural and industrial wastes are based on their conversion to single-cell protein by using them as substrates on which to grow yeasts and other fungi and bacteria for animal or human consumption. Food or animal feed is thus produced from a renewable resource without interfering with the primary productivity of agricultural land. Torula yeast (*Candida utilis*) grown on molasses or sulfite liquor has long been used in foods—but in small quantities, primarily as a vitamin source. Processing to lower its nucleic acid content will be required to make it acceptable as a significant protein source for human consumption. The same limitation applies to all other single-cell proteins, because rapidly growing cells have a high content of nucleic acid that man can excrete only in the form of uric acid. Too much uric acid leads to its deposit in the joints, causing gout, or in the kidneys, where it may lead to stone formation.

As in the case of higher plants, each new yeast, fungus, or bacterium species proposed for human use will have to be carefully screened for toxicity and allergenicity in man. Careful processing will be required to render them suitable for food use.

There is now much interest in the production of single-cell protein from petroleum hydrocarbons, and their use as food will similarly depend greatly on the ability of the food technologist to render them safe and palatable, and on the food industry to incorporate them into attractive food products. There can be little doubt that single-cell protein, in the broad sense in which the term is currently used to include multicellular lower plants such as filamentous fungi as well as yeasts and bacteria, will make an increasingly important contribution to animal and human feeding. However, the use of single-cell protein, grown on relatively pure substrates and processed for human consumption, seems almost certain to be initially limited to the processed foods of the industrialized countries, because of its high cost compared with that for protein from legumes and oilseeds.

In the past, both algal protein and fish protein concentrate have been proposed as virtual panaceas. Both



Eugene B. Skolnikoff, Director of M.I.T.'s Center for International Studies, calls North America "the Saudi Arabia of food," and this chart reveals the growing dependence of almost all the rest of the world on grain exported from the U.S. and Canada. A prolonged drought, bringing back to the midwest and western plains the "dust bowl" conditions of the 1930s, would affect most of the rest of the world and confront the U.S. with an agonizing decision of priorities. (Data: U.S. Dept. of Agriculture from the *New York Times*)

now appear too costly and unpalatable, but their proponents have not entirely given up. Leaf protein concentrate has had its strong advocates for more than two decades but is only now receiving the kind of intensive technological investigation that is required.

Fortification or "Nutrification"

Fortunately, the food technologist seeking to use a wide variety of source materials to augment our supply can, at least to some degree, correct adverse nutritional effects of processing or make up for natural deficiencies through the use of synthetic nutrients. All of the essential nutrients are now available in forms identical in biological activity with those occurring naturally in foods. Moreover, for those nutrients most likely to be limiting, costs are relatively low. There is no longer any excuse for not tailoring processed foods to the nutritional needs of man, except for continuing controversy over optimum nutrient intakes and over the most appropriate vehicles for fortification. Here food technologists have the right to expect prompt decisions from nutritionists and the appropriate regulatory agencies.

The present widespread disease associated with inadequate intakes of iron (iron deficiency anemia with impaired work performance and resistance to infection), vitamin A (xerophthalmia and keratomalacia), and iodine (endemic goiter and endemic cretinism) would not occur at all if the opportunities for adding these cheap, readily available nutrients to processed foods were utilized. Even protein deficiency could be markedly decreased by enriching selected processed foods with protein concentrates and then, if necessary, adding the synthetic amino acids still limiting in the product.

Once a consensus is reached on the desirable amount and kind of fat for optimum health and longevity, food technologists can tailor food fat content accordingly.

In short, application of nutrition knowledge by food technologists can greatly improve human health simultaneously with the introduction of novel, synthetic, and substitute foods. At the same time, he can assure that we enjoy our food just as much, or indeed more, as greater varieties of taste and texture are introduced. These developments will require the full range of professional skills encompassed by food science and technology, including food engineering, biochemical engineering, food chemistry, flavor chemistry, food processing, food microbiology, food toxicology, and nutrition, and a progressive food industry. They will also require a food industry willing to invest in research and in truly innovative and far-sighted product development.

The future of mankind will depend on the balance achieved between future food production and future population growth. It will be such a close race that scientists and technologists are likely to determine the outcome.

Nevin S. Scrimshaw's place on the Opening Plenary Session of the IV International Congress of Food Science and Technology, held in Madrid in September—where this paper was presented—attests to his prominence in that field. Dr. Scrimshaw's scientific work has resulted in a new understanding of the relationship between nutrition and the mental and intellectual functioning of man; at the same time he has made outstanding contributions to the design of food products for malnourished populations and in the administration of international nutrition programs. In his present post at M.I.T. since 1961, Dr. Scrimshaw was selected for the first Killian Faculty Achievement Award at M.I.T., "to recognize extraordinary professional accomplishments," in 1972; " . . . a scientist whose career exemplifies the ideal of science as a search for human answers to the most basic of human needs," said the citation of his colleagues.

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Technological Change in the Food Industry

The year 1973 has been chronicled by the news media as the "year of Watergate," but historians could record that an event of greater long-term significance occurred in that year. The year 1973 may well mark the disappearance of cheap food from American consumers' tables. Prices for food purchased for home consumption increased during the calendar year 1973 by 16.3 per cent, the largest increase in one year since the hectic catch-up purchasing spree of 1947. It is possible, as some Administration officials have forecast, that the current alarming rate of inflation in food prices may slacken somewhat in the future. Nevertheless, it seems almost certain that for the foreseeable future the United States will be faced with a strong continuing upward trend in food prices. The increase is expected to approximate 15 per cent for 1974, and the 1975 increase is likely to be of the same magnitude.

In 1973 food costs replaced housing costs as the largest single expenditure in the budget of the average American. Families conforming to the U.S. Department of Labor's "lower budget" for an urban family with two school age children and an income of approximately $8100 per year were forced to use 37 per cent of their expenditures for food. Because food costs are rising faster than the general price level, attention has focused upon the need for accelerated improvement in productivity and the development of new cost-saving technology in the food industry.

Current Economic Trends in the Food Industry

During the decade 1960-70 the price of food was one of the more stable items in the cost of living. Since that time a confluence of significant developments have combined to cause the runaway rate of inflation in food prices and bring about a basic change in our food price structure.

1) A fundamental change has occurred in the relationship between the American food system and the world economy. The United States, no longer insulated from the world market through high government farm supports, has recently become an integral part of the world food market. The devaluation of the dollar has made American farm products more attractive to the world market and contributed to the upsurge in American farm exports. Farm food exports increased in volume from eight billion dollars in fiscal 1972 to 20 billion dollars in fiscal 1973. In fact, one of the reasons for food shortages in the U.S. is that diets of other nations are approaching our own; many of our domestic food products are in short supply in relation to world demand. Though other nations can duplicate almost everything we make and sell, often at lower cost, as a whole they have difficulty equalling the productivity and quality of our farm output. In the years ahead, our food production will become increasingly interwoven with foreign policy and will assume a major role in our national strategy to achieve a more favorable balance of trade.

2) American agriculture is beginning to resemble industry in its organization. More and more large corporations are taking over farm operations, and food prices, historically cited by economists as examples of pure competition, may soon take on the characteristics of administered prices. Already meat is being withheld from the market in the expectation of higher prices, and wheat and corn is being placed in storage rather than being sold at market prices. The financial backing of large corporations will make possible more such stockpilings, with the result that even record crops may not produce the price reduction which would be anticipated in a perfect market.

Furthermore, equally significant changes are occurring in labor relations on the agricultural front with both the Teamsters and the AFL-CIO vying for membership among farm laborers. For many years the price of food has been subsidized by the payment of substandard wages to farm and migratory labor. That situation is changing and its impact will be felt on farm prices.

3) Unions, strongly entrenched at all levels of the food distribution system (exclusive of agriculture), are using their strength to convert the food business into a high-wage industry. The Teamsters Union controls the bulk of the food industry's trucking and warehouse operations; food processing is a business dominated by giant corporations most of which are unionized; in retail supermarkets, the Amalgamated Meat Cutters and Retail Clerks Unions have organized most of the large retail food chains of the nation. Although most jobs in retail food stores are relatively simple to perform, wage scales are high. On the west coast, for example, a cashier in a unionized supermarket can earn $13,000 per year.

Wages in the retail sector of the food industry are high and rising higher. Since the termination of wage and price controls, wage adjustments in the neighborhood of 15-20 per cent per annum, including fringes, have been negotiated. Store wages in the industry have risen an estimated 35 per cent since 1970. Since labor costs represent over 50 per cent of all operating

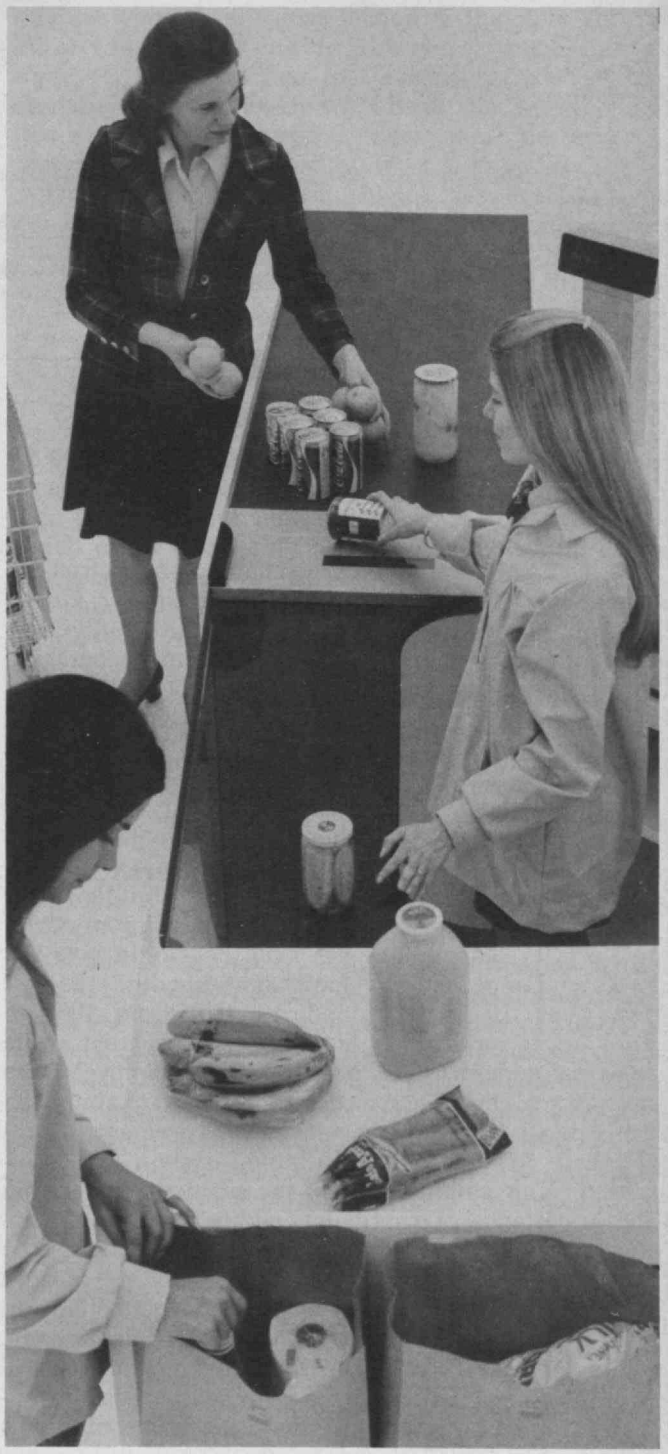
The checkout scanner will soon replace the cash register in many large grocery stores. To register an item, the checker places the Universal Product Code symbol printed on each package over the scanning window at the end of the checkstand. The system automatically decodes the symbol, shows the product name and price on the terminal display panel, and prints a receipt with the description and price of each item for the customer.

costs at the store level, wage adjustments of this magnitude will obviously lend further upward impetus to price increases.

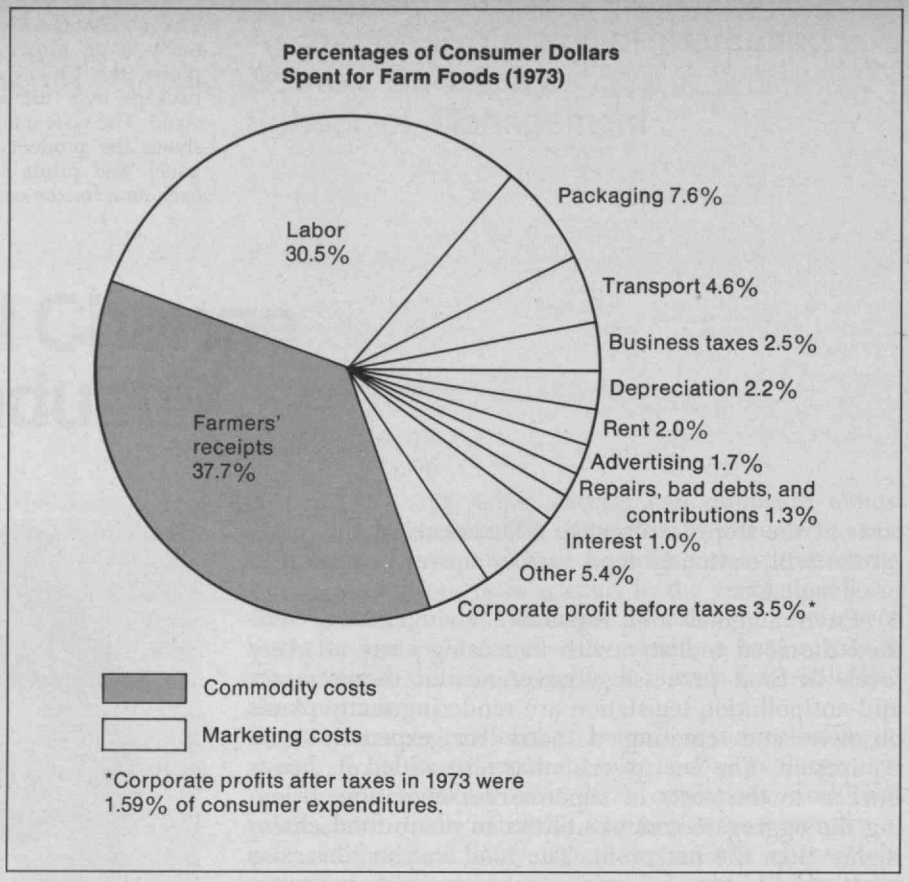
4) Environmental and legislative changes have saddled the food industry with increasing costs at every level. In food processing, governmental requirements and antipollution legislation are rendering many plants obsolete and creating a need for expensive new equipment. The energy crisis has also added its heavy burden to the costs of supermarket operation, bringing the aggregate cost of utilities in many food chains higher than the net profit. The food industry has also been the target for various consumerist measures which, though they may produce psychological or environmental benefits, also unfortunately raise operating costs. Thus laws requiring the posting of unit prices, environmental controls which ban the use of nonreturnable bottles, and similar regulatory legislation all have impact upon the cost of food on the table.

Rising costs pose problems in any industry, but in the food industry they should cause the public special concern. The American food industry is basically a pass-through industry; when costs increase in other industries, rising imports or reduced consumer purchases may moderate the impact of the increase. But when costs rise in the food industry, people must still eat, and foreign imports offer no respite. Furthermore, the profit margin in the industry is so small that there is no real possibility of squeezing profit to absorb some of the cost increases. As a matter of fact, U.S. Department of Agriculture data for 1973 show that corporate profits after taxes of all firms engaged in transporting, processing, and distributing domestic farm food products took only about one and a half cents out of every consumer's dollar spent on such products.

Newspaper headlines referring to large profit gains by the retail food chains may have created the impression that the chains have a large profit margin. In actual fact, the fiscal year 1972-3 was one of the worst years of all time for retail food chains in terms of profit performance. Total net earnings after taxes fell to .49 per cent of sales, while profits as a percentage of net worth fell to 5.63 per cent, far below the average for all industry. For the fiscal year 1973-4, profits are likely to rebound to about .8 or .9 per cent of sales. Even this figure, which would represent a huge percentage increase, will not bring the industry back to the average profit performance of the pre-



Thirty cents out of every dollar consumers spend on food goes for labor costs. In contrast, corporate profits before taxes take only 3½ cents. If food prices are to be reduced, progress must be made in cutting the labor costs of distribution through automation.



vious decade, or to a reasonable rate of return on investment.

Avenues to Increased Productivity

Can increasing productivity be counted on to offset the impact of rising costs in the food business? Unfortunately, technological progress in the distributive sector of the food industry has not had an encouraging history. One has only to take an objective look at a retail supermarket to realize that operations are essentially unchanged from what they were 25 years ago. Adoption of the self-service concept has simply substituted the labor of the customer for the labor of the market employee. Meanwhile, grocery clerks still load the shelves by hand, each item is laboriously price-marked individually, and cashiers ring up the price for every item purchased. Improvement in productivity in store level operations has been negligible over the years and may actually have diminished in the last two years. Recent data indicate that from 1963 to 1973 prices for food at home rose 55 per cent while sales in supermarkets per full-time employee rose only 36 per cent. Therefore, the challenge to American business is: How can the rate of improvement in productivity in the food distribution system be accelerated? This emphasis is not meant to derogate from the importance of continuing efforts to improve productivity in agricultural production. However, the fact is that productivity in agriculture has increased annually two to three times as fast as productivity in the marketing and distribution system. Furthermore, while both the Federal and state governments as well as various foundations expend millions of dollars annually furthering research into new strains of grains and cattle, research for improved food distribution has no such support.

There appear to be three major avenues to increased productivity in the food distribution industry. All three approaches commonly recognize the need for viewing the food industry in its totality as a system and seek to eliminate inefficiencies and accelerate technological progress through cooperation of business, government, unions, universities, and other institutions.

1.) *Cooperative Efforts Among Firms and Between Industries.* An objective look at the food industry clearly shows that major system inefficiencies exist in the no-man's land between companies. Frequently governmental regulations or institutional factors make it impossible for an individual firm to achieve any breakthrough without the cooperation of government and other firms. A case in point is transportation. The average railroad car moves only 12 per cent of the time and moves with a load only about 7 per cent of the time. Yet the food industry—as well as other industries—suffers from a shortage of railroad cars. According to industry sources, the average elapsed time for shipment of produce from the west coast to the east coast has until recently been about 11 days. Furthermore, the reliability of railroad commitments as to delivery dates has been so low that most companies carry safety stocks, adding another unnecessary cost to the price of food on the consumer's table. Though the National Association of Food Chains undertook a study in 1966 which demonstrated that a unit train running from the west coast to the east coast was feasible and could cut elapsed travel time to less than 4 days, nothing was done to implement that study because no machinery

existed for bringing pressure on the railroads to change their traffic policies. No progress was made until the National Commission on Productivity was established and took an interest in the project.

Today, as a result of prodding by the Commission and cooperative efforts by the food industry and railroads, the Union Pacific has inaugurated a "Fresh from the West" through train which makes the cross country trip in seven days. The consumer gets a fresher product, and more significantly, a major saving has been effected in the use of railroad cars. According to National Commission data, the load-to-load cycle time has been reduced from more than 30 days to 21 days. If we assume that an average of 100 cars per day in season are hauled on this service, the total cars needed to provide the service has been reduced from 3000 cars to 2100 cars—leaving 900 cars that could be used elsewhere. At $45,000 per car, this is the equivalent of a $40 million investment that otherwise would be required to produce the same level of service. The progress with respect to rail transportation illustrates the concrete benefits which flow from industry cooperative efforts. Such efforts can also form the basis for application of improved technology.

2.) *Standardization.* Frequently, standardization is an essential prerequisite to the application of new technology. Agreement among all major segments of the food industry as to the nature of a Universal Product Code and the symbol to embody it was, in retrospect, a most critical and time-consuming phase in the development of automated checkout systems for the food industry.

There are other areas where standardization can reduce costs by making more extensive use of automation possible. A prime example currently receiving careful scrutiny is the reduction of the disparities of size in the shipping cartons for dry groceries. An actual count in a retail distribution warehouse showed 2587 different size shipping cartons in a dry grocery section stocking 5000 items. Such diversity makes automatic handling difficult. A system of modularized shipping containers—where variation in dimensions of shipping cartons would be limited and permissable modules would be related one to the other so as to fit securely on a pallet—has been suggested and could save one to two cents per case, depending upon the kind of warehouse operation involved. Savings in pennies per case may not seem significant until it is noted that some 15 billion cases are handled annually in the food industry, a possible savings of between $150 and $300 million a year. Although the potential benefits flowing from modularization are great, the task is a formidable one and probably can be effected only over a period of years, possibly in connection with industry efforts to conform to a national metrication policy.

3.) *Accelerated Development of New Technology.* The lack of rapid technological development in the food industry is, at first glance, a rather surprising phenomenon in view of the characteristics of the industry. The food business is noted for its repetitive, high volume operations. At most levels of the industry, labor costs are a significant portion of operating expenses and labor rates typically are high. From the point of view of the new equipment supplier, equipment designed to meet the needs of one particular company would probably meet the needs of other companies in this replicative, competitive market. All of these factors should tend to make for rapid development of labor-saving new technology.

Why has such development not occurred? First, the food industry by and large is service and market-oriented, rather than operations or technology oriented. In supermarket operations, many new labor-saving devices have failed to make inroads; while operationally efficient, they have had serious shortcomings from the merchandising standpoint. The "automatic market" has been talked about for years (a prototype supposedly will open in Japan in 1975) but the industry has shown little enthusiasm for this concept because the system is likely to discourage impulse sales. The typical automated market concept involves the display of one of each kind of item behind a glass door. The customer places a card in a slot which activates selection of the product from a warehouse section of the store and its transfer to the front end for customer payment and acceptance. Operators fear that under this concept the customer would buy only what he or she "needs"—and that would have an adverse effect upon sales and the gross profit mix.

A second barrier to technological advance has been the lack of attention to technological research in the industry and the lack of staff personnel with engineering capabilities. Although food technologists are in demand in large processing companies, there are few engineers in the employ of even the largest retailers and wholesalers in the food industry. As a consequence, there is a massive communications gap between the food industry and the engineering community. The industry has not been able to articulate its needs in engineering terms, and the engineers are unaware of the industry's needs for new technology and of the payoff which exists if certain kinds of operational problems can be solved by innovative equipment design.

A third problem is the continually mounting variety of products which must be handled in limited facilities. A supermarket or food warehouse is like a little black box into which more and more items must continually be packed yet handled with maximum efficiency—the number of items carried in wholesalers' warehouses, for example, increased from 5100 to 7300 between 1960 and 1970. This problem has been accentuated by inflation, at least as far as warehouses are concerned. Buyers purchase large lots of items because prices are skyrocketing or they fear that there will be shortages, and then leave the harried warehouse operator to find some place to store them. Here again operational efficiency gives way to the paramount objective to increase sales and serve the needs of the consumer.

The inadequate profit margins of the industry, the depressed stock prices of most publicly traded companies, and the difficulty of obtaining and servicing new capital needs present the fourth problem. The introduction of the automated checkout will itself impose a huge capital expenditure burden upon the industry. The rate of introduction of known improvements in technology may be slowed by the shortage of capital within the food industry.

Despite these problems, when a technological possibility offering increased productivity as well as greater consumer service becomes available, the food industry has demonstrated an ability—albeit slow—to take the necessary steps to transform such a possibility

to reality. An examination of the history of the development of the Universal Product Code and automatic checkout indicates the various steps that are essential to the development of new technology in this industry: articulation of the needs, industry cooperation to achieve standardization, transfer of technology from other fields, and ultimate introduction into everyday operations. Review of these steps in the context of a major innovation may suggest ways in which the entire process can be accelerated, hastening other much needed technological improvements.

The Automated Checkout—A Case Study

Prior to the advent of the supermarket there was little need for automated order totalling or checkout. True, adding machines were used to tally sums, especially for charge and delivery operations, but the typical grocery purchase involved only a few items and was easily handled by clerks who figured the amount due in their heads, or with a pencil on the side of a shopping sack.

Supermarket selling imposed new constraints. Customers shopped less frequently for far larger orders. Their purchasing was concentrated in comparatively few hours each week. Furthermore, the shopping process was such that checkout was viewed as an unproductive bottleneck—an inglorious end to an otherwise exciting expedition.

To solve this problem, chains and manufacturers developed special checkstands. Moving belts, turntables, special shopping carriages, bundle take-out systems and other features eventually were incorporated. Early model electro-mechanical cash registers did little more than add, but later versions were capable of sub-totaling taxable sales and maintaining departmental sales records. However, to this day the checkout process continues to be a costly, labor intensive function resented by both retailer and customer.

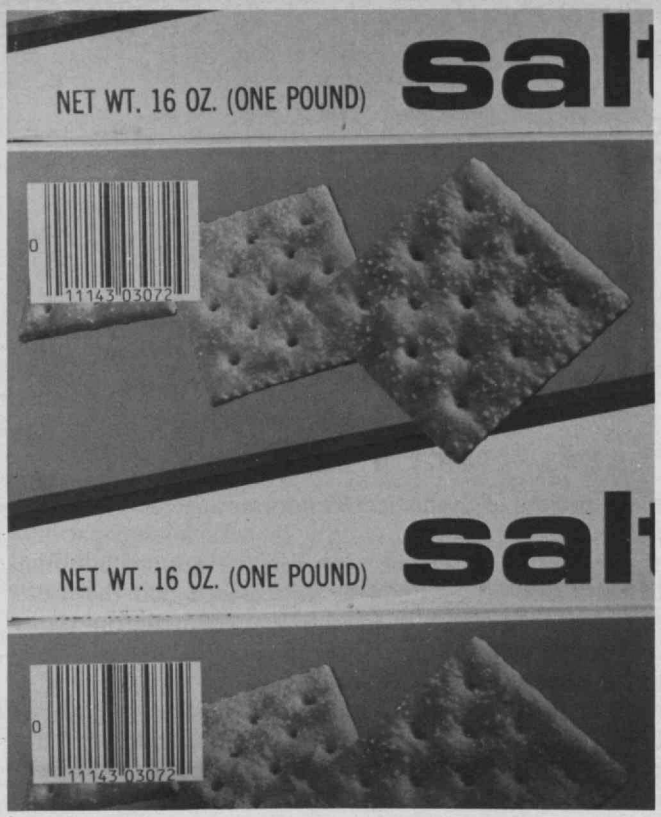
Automating the process is straightforward. All that is required is a device to "read" price (or a code) directly from each customer purchase without the aid of human character recognition. Given the direct transfer of information from each item sold to some kind of register, orders can be tallied and sales records maintained. The use of codes (as opposed to only price) enables capture of item movement, departmental sales, and other data, but requires a more "intelligent" register with memory and price look-up capabilities.

Early efforts to design such a system go back to 1932, coincidentally the date of inception of the supermarket. Over the intervening years large companies invested significant sums in feasibility studies and development work. Various technologies were tried including phosphorescent emission and photo-electric optical scanning. However, while these efforts suggested that systems might be developed which would be technically feasible in the narrowest engineering sense, they all fell far short of economic viability when measured on a cost-benefit basis. More recently this situation has changed radically—first as the cost of computing has decreased exponentially, and second as laser scanning technology, originally developed for other uses, has been applied to the problem of symbol scanning.

Meanwhile, discussions went on in the food industry between manufacturer and retail groups as to how a system could be devised to uniquely identify each separate item carried in a supermarket. Developing a universal code which would both suit the needs of manufacturers and retailers, and also take account of the fact that supermarkets sell many nonfood products in common with other types of stores—stores which were at the same time attempting to develop their own coding systems—proved to be a thorny problem. Finally in 1970, food processors, wholesalers, and retailers, in an unprecedented joint effort, established the Grocery Industry Ad Hoc Committee to determine the feasibility of a Universal Product Code and, if feasible, to recommend the most desirable code and symbol to represent the code.

Funding of over one million dollars was obtained from the industry, and a demanding schedule to achieve the objectives of the Committee was met. The feasibility of a Universal Product Code was affirmed and a 10-digit code was agreed upon. This code specifically excludes price, expiration or manufacture dating, plant location and similar information. Rather, it is devoted exclusively to identifying each product uniquely by assigning a five-digit manufacturer ID and, in turn, having manufacturers assign and register five-digit numbers for each of their products.

The next problem to be surmounted was the choice of a symbol which would incorporate the code and which all vendors would be requested to place on their products at the time of manufacture. The problem was compounded by the fact that during the mid-sixties, various companies had begun to develop automated checkout systems incorporating scanning using their own proprietary symbols—and for the most part these various symbols were incompatible in that they could



The Universal Product Code will be displayed on 50 per cent of all supermarket products by the end of 1974. The first five digits of the code and corresponding bars identify the food manufacturer; the manufacturer uses the last five digits to identify each separate product and package size.

not be read by devices of other equipment manufacturers. A Symbol Selection Subcommittee of the Grocery Industry Committee was formed to resolve this dilemma. To insure that the symbol and scanning technique selected would not freeze the industry into a system which might in a few years become obsolete, the subcommittee asked a group of M.I.T. scientists to assess possible future technological developments. In April 1973, the Subcommittee announced its choice—a bar code, which using laser technology was omnidirectionally machine-readable. The symbol was placed in the public domain and all food manufacturers were requested to use it.

Adaptation to the new symbol by equipment manufacturers was fairly rapid and, by the spring of 1974, a dozen companies were showing prototype checkout models at the Super Market Institute industry meeting. These systems utilized laser scanning devices to "read" the Universal Product Code symbol from merchandise as it passed over each checkout counter. Electronic cash registers permit manual code or price entry for non-symbol marked packages. An in-store mini-computer controller provides for price look-up and data storage. At the time of this writing manufacturers are engaged in a race to sign up retailers for "production model" installations. Most supermarket chain commitments involve equipping one store during late 1974 or early 1975 for extended evaluation.

While there are important details yet to iron out, it is apparent that there are no longer technological barriers to the successful operation of automated checkouts. There are *engineering* problems—to incorporate symbol printers into in-store, variable weight production lines for meat and produce, to affix symbols to those items not code marked by manufacturers, for manufacturers to devise means of symbol-marking difficult-to-mark packages such as soft drinks and beer—but, in the larger sense, these are relatively insignificant problems. Questions of acceptance of the automated checkout by unions and consumerists (as opposed to consumers) are not trivial, but they seem tractable given appropriate industry attention. The critical question is the economic viability of the equipment.

Economic Viability

As already noted, early automated checkout concepts grossly failed the test of economic viability. Now the question is more subtle, with the answer depending upon criteria and conditions unique to particular chains. For example, companies with large, high-volume stores, as opposed to large chains per se, will find the concept more appealing than will those with smaller units. Likewise, those with higher wage rates, more sophisticated operating systems, and greater financial resources will likely be attracted to the concept. Clearly, there is little prospect of all supermarkets converting to automated checkouts, nor is there even the likelihood that all new stores will utilize them. This raises the future complication that many companies will find themselves operating in dual mode with both conventional and automated checkouts. In some instances this prospect will deter companies from adopting automated checkouts; in other instances recognition of the many problems inherent in operating under such a dual mode could provide the impetus for converting some units for which automated checkouts could not otherwise be justified.

The elimination of price marking and cash register key-punching is typical of so-called "hard" savings which are subject to straight-forward measure. The many test installations currently being undertaken are intended to confirm advance estimates of these savings. While the total will vary by store within firm, as well as by firm, it is likely that direct savings will be substantially in excess of one half of one per cent of sales. However, given the state of symbol printing technology and the necessity to share benefits with consumers and clerks, it is unlikely that the more optimistic estimates of savings of one and one-half to two per

The retail food industry, long backward in incorporating new technology, is beginning to catch up. The automatic checkout system may be the forerunner of other engineering innovations that will bring food to American consumers more quickly and efficiently.

cent generally will be realized. Even so, the magnitude of projected savings can best be appreciated when it is compared to current supermarket profits which, as noted, average about 0.8 to 0.9 per cent. Essentially, anticipated "hard" savings (before taxes) are equivalent to current total after-tax profits!

Less tractable are so-called "soft" savings, most of which are in the form of information provided to chain management, involve benefits which may or may not be realized depending upon other developments such as the advent of "cashless" transfer of funds, or are classified "soft" because they are difficult to measure. Virtual elimination of ringing errors and improved pilferage control, promotion, evaluation and scheduling will yield important, if yet indeterminate, savings. It is the authors' opinion that initial adoptions of automated checkout systems will be based on "hard" savings, much in the fashion that early computer installations were justified on their bookkeeping value; but that their contribution in the area of "soft" benefits will, in the long run, have a more radical impact on the industry.

Manufacturers currently are promoting the ability of their equipment to provide all types of information to store managers and chain merchandisers. However, it will be several years at best before companies are able to make refined use of this data. At first, management personnel will have trouble enough accommodating a flood of new information. Initial efforts will be devoted to improving employee scheduling, to analyzing movement of key items (especially those for which computerized warehouse withdrawal information has been lacking, such as perishables and store-to-door delivery products), and to improving funds control and store accounting. It will be several years before systematic use is made of sales data to tailor product offerings and promotions to specific clientele, and automatic reordering based on store sales data may be even further in the future.

On the cost side, equipment manufacturers are quoting $90,000 to $120,000 per store for a typical eight-unit installation. However, these figures do not represent the total commitment required. Not only are there important one-time equipment and software installation costs, but the cost in management time is so substantial that it must explicitly be recognized. Again, it is not the one-time cost of go:no-go decision-making or the managerial attention necessary to effect system introduction; critical are the on-going costs of up-grading or expanding store and headquarters personnel to utilize the new flow of sophisticated information. Of course, to the extent companies use only the checkout capability of the equipment, these costs can be minimized. But, like the computer, it can be anticipated that the automated checkout, while incredibly productive in terms of output, will require substantially increased managerial tending.

How do these benefits and costs net out? Without begging the question, as already noted this will depend upon the individual situation. The greatest direct benefits will accrue to those firms with the biggest "gap" to close. The most efficient companies may realize only slim initial advantages because of their present level of relatively sophisticated operations, but ultimately these are the firms which will derive the greater benefit. Adoption of the automated checkout may be an important factor in the differentiation of a new class of very large, high-volume stores from conventional supermarkets. Whether the hyper-marché, superstore, or simply a very large supermarket is taken as the model, it seems that a critical mass itself fosters market differentiation by making practical such specialized "boutique" offerings as the florist shop or cheese counter; by increasing operating efficiency through work specialization and material handling; and, now, through the efficiencies of automated checkout. As these large stores attract business, their distinctiveness vis-à-vis surviving smaller stores will become more evident to shoppers, thus intensifying the cycle.

Rate of Diffusion

What will be the extent and rate of diffusion of this system? One important variable is the degree to which manufacturers print the Universal Product Code symbol on their products. Most important suppliers have already incorporated the symbol in their packaging or have made plans to convert when existing stocks of packaging supplies are consumed, or, in the case of annual crops, at the time of the next major processing. The goal of having 80 per cent of all products symbol-marked, the level commonly cited to make scanning practical, will present no problem. After 1975, retailers will bring tremendous leverage to bear on recalcitrant firms, and the possibility of lost business will force conversion except in the instance of certain imported, slow-moving and special problem items.

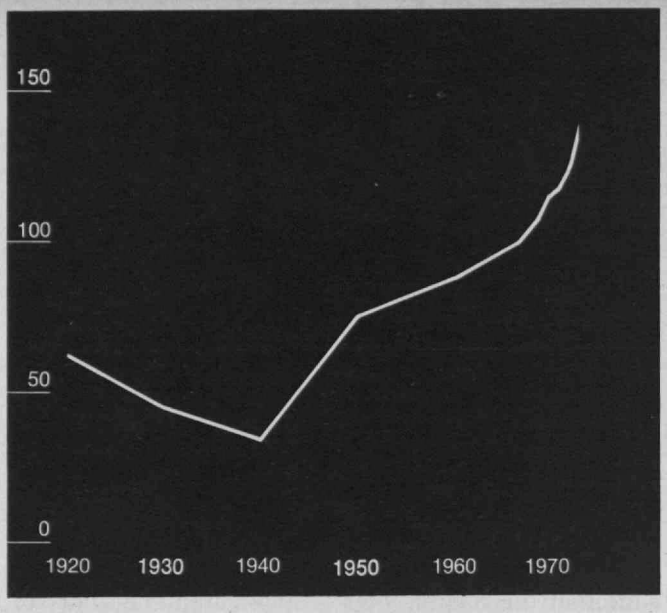
A second important factor will be the cost of equipment. It is likely that two or three firms will capture the largest part of the market and that these firms will en-

joy the benefits of "riding down the cost curve." While price drops of the magnitude recently evident for hand-held computers are extremely unlikely, it is possible that the relative cost of automated checkout systems will decrease—although inflation probably will preclude significant absolute price reductions.

As is true for most innovations, lack of awareness of the development will not be a factor. Already a deluge of information has appeared in the trade press. Unless early production models in tests fail to meet widely held current expectations, it is likely that most major chains, and many regional chains with high-volume stores will have installed one or more systems within three to five years. Thus, in response to the pressing need of the industry to realize productivity gains in the face of ever increasing cost pressures, the rate of diffusion of this innovation among chains probably will be faster than for innovations in general, but by no means so fast as for those innovations which enjoy rapid acceptance.

The rate of diffusion within companies is a separate question. Clearly it will take a year or more for early adopters to determine the costs and benefits which they can expect over the long run. Taking into consideration the problems of limited capital, heavy investment in existing equipment, strong labor unions, etc., it is unlikely that any significant number of companies will achieve 90 per cent conversion in less than four or five years. Consider, for example, a regional chain or division of a national chain having, say, 150 large stores. The capital requirement would be considerable. Suppose automated checkout systems, including in-store symbol-marking devices and other peripheral equipment, cost $140,000 per store; total investment would be $21 million! If the average sales per store were $5 million per year (as opposed to the current average of $3.2 million for all firms), and assuming annual operating savings of one per cent of sales, accelerated depreciation over an eight year life, and current tax rates, the after-tax incremental return on investment (ROI) would be nearly 30 per cent compared with alternate manual-entry electronic or mechanical systems without scanning capabilities. If annual operating savings amount to one and a quarter instead of one per cent of sales, the after tax incremental ROI would be nearly 40 per cent.

Ordinarily, these returns would be looked upon favorably. However, given the large investment required, the questionable accuracy of the cost-benefit



The current rate of food price increase has not been equalled since World War II and the following decontrol period. The Annual Average Consumer Price Index of the Bureau of Labor Statistics (1967=100) shows that prices have risen by approximately the same amount since 1967 as in the 20 years before 1967.

assumptions, prevailing high interest rates and potential consumerist objections, the answer is by no means clear. If the cost-benefit estimates of manufacturers are confirmed in systems field tests now underway, the adoption of the automated checkout system should proceed as projected above—but if less favorable results obtain, chains may very well opt for systems without scanning capability until the economics shift.

Engineering Lower Food Prices

The time required for application and diffusion of an invention in an industry can be overly long, creating a situation where invention seems to crawl at a snail's pace while inflation accelerates its speed with each passing year. The contrast in these two critical trends raises some important questions:

What determines the rate of technological development in an industry? What can be done to reduce the time from gestation of an idea to its actual introduction? Can an industry develop better communications with the engineering community, focus attention upon its needs, and stimulate a flow of new technological improvements in a shorter time frame? To what extent can the pace of technological innovation be controlled?

During the past year an interesting experiment has begun at M.I.T. which is seeking answers to these questions. This program—TAFI (Technology Applied to the Food Industry)—funded by the National Commission on Productivity and Work Quality, is spearheaded by an inter-disciplinary group of M.I.T. faculty: Gordon F. Bloom, Senior Lecturer in the Sloan School of Management; Samuel A. Goldblith, Underwood-Prescott Professor of Food Science; and Murray Eden, Professor of Electrical Engineering.

The program's objective has been to bring together engineers who have little knowledge of the food industry but have an interest in possibly developing technology for it, and industry executives from food processing, transportation, warehousing and retailing functions, who are familiar with operational needs in these various areas. To this end, the TAFI project has interested a group of about 350 engineers and representatives of the food industry in discussing industry needs and learning what the payoff could be if particular operational problems could be solved. The engineers' interests are quite diverse: some in information processing, others in materials handling, still others in energy utilization. To accommodate these various interests, a series of work shops were held focusing on various needs in the food industry within specific problem categories.

Space does not permit more than a sampling of the wide variety of ideas that were explored at these meetings:

1.) Shelf price markers: If wide adoption of the Universal Product Code and automated checkout eliminates individual product price marking, it will become increasingly important that price changes be transmitted promptly to shelf markers, since this will be the only price information available to the customer while shopping. Presently, when prices are changed at headquarters in a supermarket chain, new strips for shelf markets are printed and sent to the stores via intra-company mail, distributed via truck deliveries. Since many stores do not receive a daily truck delivery from the chain warehouse, the change may not be made in the shelf price marker until several days after the price has changed in the computer. This time lapse cannot be tolerated under the automatic checkout system; price changes at headquarters will immediately be recorded in the minicomputer at store level and the customer will be charged the new prices. Therefore, the shelf marker must be changed at the same time.

The solution: a low cost, high speed printer at store level which can be activated over telephone lines from headquarters and print out the price changes for prompt insertion on shelves.

2.) Customer pilferage control: Customer pilferage, a growing problem in supermarkets, adds to the cost of food. Pilferage in our urban centers may amount to 1 to 2 per cent of sales—or more than the net profit of the company. The development of the automatic checkout with symbols on merchandise and a scanning capability at the checkout may suggest a means of controlling pilferage. Supermarket operators are not wor-

ried about the theft of a can of soup—it is the theft of items like Polaroid film or crabmeat that needs control. A method of determining when certain high priced items are taken from the store without going through the scanner is needed.

The solution: a method of using the product's identification code, possibly by further impregnating the manufacturer's symbol with some material that would activate an alarm and alert the management if the item left the store without passing through the scanning device.

3.) Automatic shelf-stocking: The automatic checkout can eliminate the need to price individual cans and packages of merchandise. This may open up new possibilities of getting merchandise onto shelves with less labor. At present, industry sources estimate that the function of taking product out of a case and putting it on the shelf costs about 15 cents per case.

The solution: a new automatic method of filling shelves with dry grocery merchandise.

The retail food industry is cooperating with this project in a unique manner. The National Association of Food Chains is canvassing its membership to accumulate ideas as to technological needs. It is hoped that these can then be enumerated in what, in effect, will be an "industry shopping list" which can further pinpoint the industry's needs. One of the great deterrents to new technology development has always been the risk that, even though an idea is technically sound, there would be no financially viable market for it. The process now being followed by the food industry and the TAFI project may eliminate some of this risk by clearly spelling out the nature of the need, identifying the cost-saving which could be effected, and assigning a priority to certain innovations based upon the appraisal of leading firms in the industry.

A word of caution is in order. It would be a mistake to believe that some new technological discovery is somehow going to reduce the price of food by 10 per cent. Progress can come only from the cumulative effect of a large number of technological advances, each relatively minor in its own impact. Even the automatic checkout—which represents a major technological breakthrough for the industry—could, if generally introduced, produce at most only a one per cent reduction in costs and prices.

Nevertheless, acceleration of the pace of technological change offers the promise of some lessening of the inflationary spiral in food prices. Over a period of years it seems reasonable to believe that the rate of annual improvement in man-hour output in food distribution might come to approximate that in agriculture—which until recently has varied between 5 to 5½ per cent per annum. Such a rate of change will take time to achieve; it will require industry cooperation and the support of the engineering community. If we could attract the same commitment by government and the scientific community to food industry technology which has in the past characterized aerospace development, perhaps we could score a breakthrough which, while less glamorous than our space exploits, would be more meaningful to the average American.

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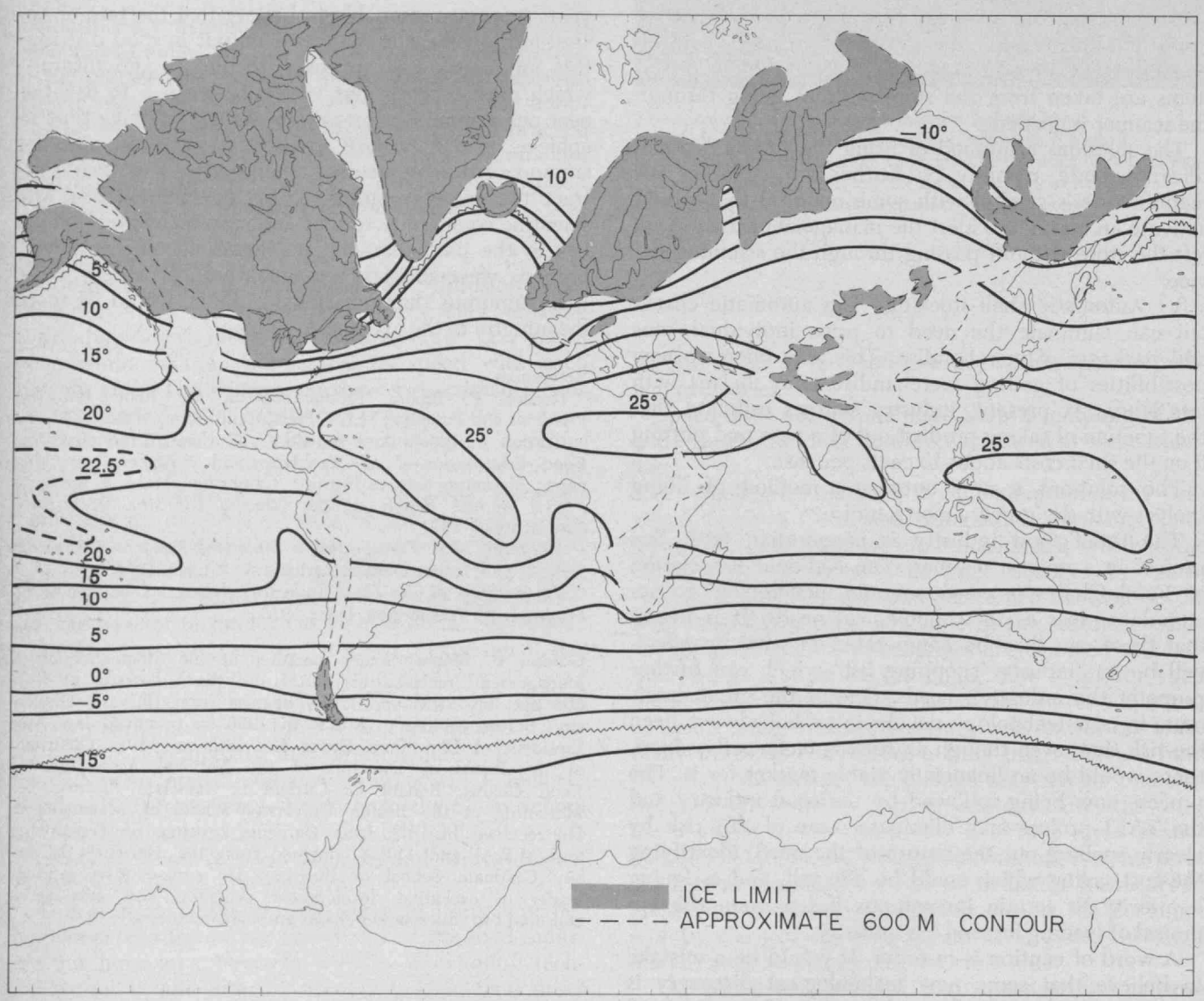
Small climatic changes can decrease harvests and cause famines. When we learn what causes Ice Ages, we may also become able to anticipate the smaller variations.



The average surface air temperature in July, 20,000 years ago. Ice sheets had been advancing for several thousand years, and were now at their greatest extent. The heavy lines on the map are isotherms—lines connecting locations with the same temperature. The pattern they reveal is fairly regular in the Southern Hemisphere, where expanses of ocean are largely uninterrupted by land masses. In the Northern Hemisphere, ice sheets (grey areas) reached almost to London's present location, where the average summer temperature was greatly affected: it was about 5°C., compared with 18° now. Isotherms have not been drawn in areas where the land rises above a 600-meter altitude, since air is normally cooler at increasing elevation, and this effect obscures the temperature changes associated with Ice Ages. The map is based upon available evidence on treeline and permafrost positions of 20,000 years ago, data on pollen distributions, and deductions of air temperature over the oceans from an analysis of the literature on sea water temperatures of the past. The map was created by Sharon Gould-Stewart, an M.I.T. undergraduate in Earth and Planetary Sciences, and Minoru Tinaka, an M.I.T. graduate student in Meteorology.

Reginald E. Newell
Professor of Meteorology
M.I.T.

The Earth's Climatic History

During the past several million years, the earth's climate has been marked by a series of alternations between glacial and interglacial conditions. Temperate forests in Europe and North America have repeatedly given way to tundra and ice such as are now found further poleward. Ice has accumulated in the Laurentian and Scandanavian areas until it covered the hills and mountains to heights of three kilometers, as it does now only in Greenland and the Antarctic; and it has crept southward and westward over North America and spread over northwest Europe, slowly shaping the landscape as it advanced. Even near the equator, glacial ice has appeared on the highest mountains in Africa and South America, more or less in synchronism with ice in the Northern Hemisphere. In the oceans, extensive ice sheets have connected Iceland, Greenland, and Labrador, and joined them eastward to Scandanavia; and ice sheets in the Southern Hemisphere have also extended considerably beyond their present limits.

There have been about six of these cold periods in the past half million years, and records back to several million years ago show evidence for more ancient alternations, although their exact dating becomes more difficult with increasing remoteness in time. The most recent cold period began about 70,000 years ago, and Richard Flint, Professor Emeritus of Geology at Yale, estimates that at the glacial maximum 20,000 years ago, some 44 million square kilometers of land were covered with ice, compared to 15 million today—a difference which amounts to about 47 million cubic kilometers of water. As this quantity was deposited as snow at high latitudes, the volume of the oceans decreased by the same amount, corresponding to an average sea-level fall of about 130 meters. About 15,000 years ago, the glaciers began to recede quite rapidly, though in an erratic fashion, interspersed with periods of new advance. Conditions improved. Flora and fauna spread poleward again, accompanied by man, and by 3000 B.C. it was even a little warmer than today in middle latitudes, enough so that the climate of that time is often known as the "climatic optimum."

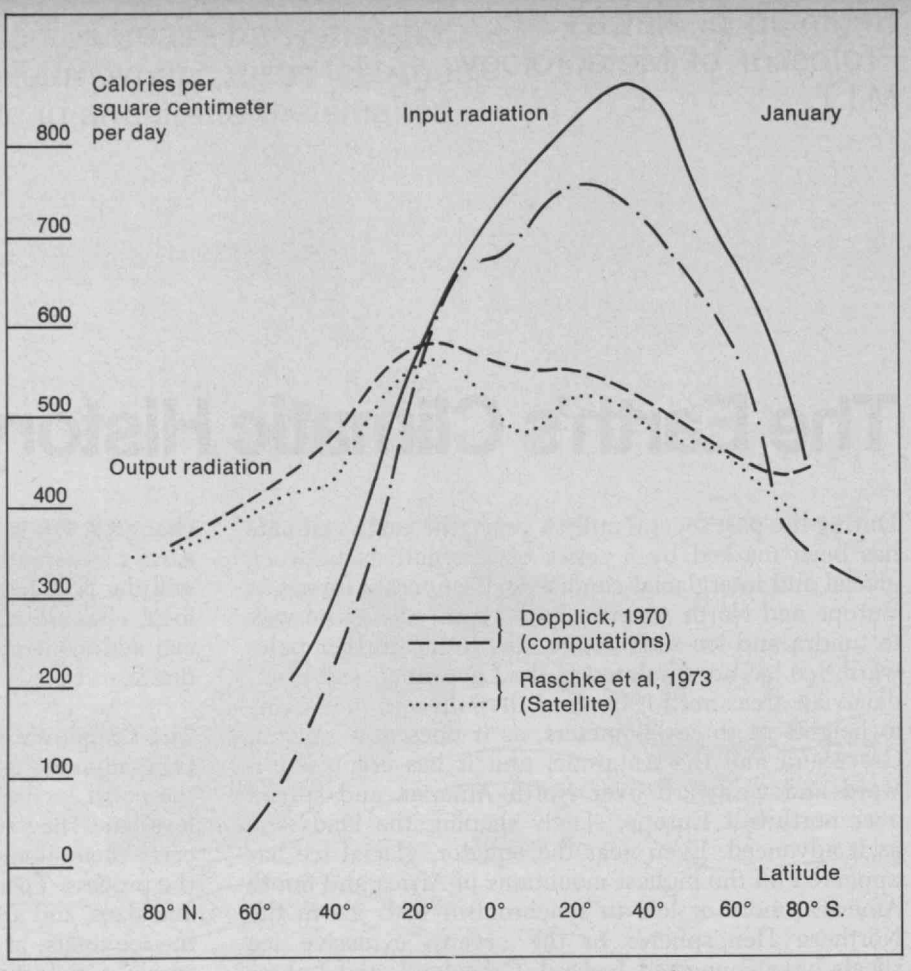
An international interdisciplinary effort is currently underway to learn in more detail this climatic history of the earth, with most attention presently being paid to events of the past million years. Ancient beetles, tree pollen, ice, and oceanic organisms are among the records being examined to reconstruct climatic patterns of the past. The resulting montages present us with major questions: Do Ice Ages begin because the sun's output changes? Or is there an internal adjustment of the earth's ocean-atmosphere-land energy balance? When will the next Ice Age start? What are the prospects for local climatic changes in the near future? Before we can address such questions, we must assemble the evidence.

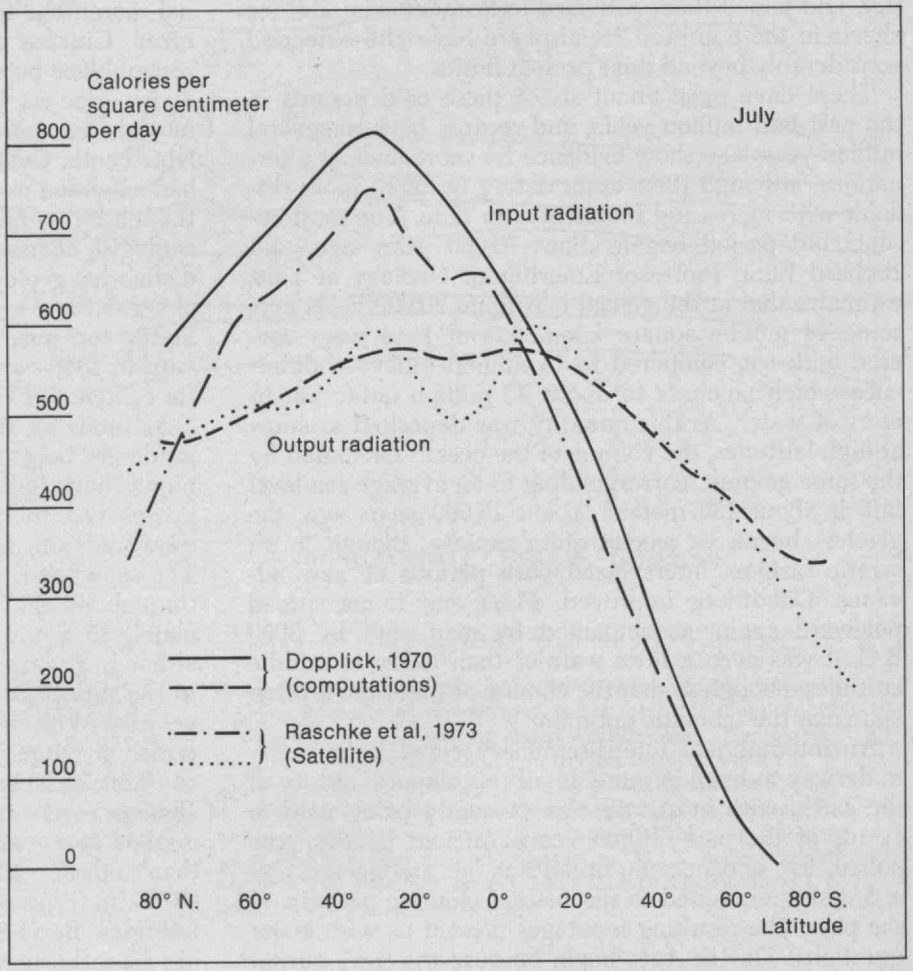
The Temperature of the Past

Contemporary glaciers are known to mark the face of the earth in distinctive ways. They cut U-shaped valleys, and they scour loose rocks from the surface and carry them along, often scratching the rocks beneath in the process. These rocks, known as till, are of all shapes and sizes, and are found in abundance in regions where the ice melts; at the end of a glacier's advance, for example, a collection of ice-borne material called a terminal moraine is formed and can often be clearly recognized. Citizens of Switzerland and Norway noted the resemblance between such distinctive features of recent active glaciers and similar surface features well removed from comtemporary ice regions, and in the early Nineteenth Century began to speculate that glaciers had extended over vast areas of Europe in the past. Although by no means the first, Louis Agassiz, a Swedish zoologist, championed this view that some of the earth's distinctive geological features had been shaped as part of a great Ice Age. His view was accepted in the United States—he was, in fact, appointed a professor at Harvard in 1846—and a close look at the geological record for evidence of Ice Ages began.

Methods for the assessment of ancient climates have gradually become more sophisticated as modern techniques have been applied to the problem. An early approach was to estimate changes in the altitude of the snowline from the landforms associated with glaciers. The snowline is the level above which snow is present throughout the year, and thus corresponds approximately to a mean summer temperature of about 0°C., although it varies with the slope of the land, exposure to the sun, proximity to water, precipitation, and wind velocity. With the assumption that the mean vertical decrease of temperature in the atmosphere has remained constant at about 5.5°C. per 1,000 meters, snowline changes can be translated to temperature changes. This method gives values for 20,000 years ago that are lower than today's: about 5°C. lower at low latitudes, 8-10°C. in central Europe, and even more at higher latitudes. Beryl Simpson of the Smithsonian Institution has recently summarized work in South America which

Heat gained by the earth from visible and near-infrared solar radiation, versus heat that the earth loses to space as infrared radiation. The input depends on the play of sunlight over a sphere, and spherical geometry dictates that the change with latitude ought to resemble a cosine curve, which it does. The output, depending on the loss of heat from the ocean, land masses, and the atmosphere, is more complicated. In January (top chart), latitudes above about 20° in the Northern Hemisphere and about 70° in the Southern Hemisphere lose more heat than the sun provides. To compensate for this loss, heat flows from low latitudes, as shown by the numbers in the table on page 35. The complementary situation for the month of July is shown in the bottom chart. Two methods were used to produce the curves shown here. The first (Dopplick, 1970) relied on earth measurements and a theoretical model; the second (Raschke et al, 1973) made use of satellite measurements of incident solar radiation and the earth's reflectivity. The results are in close agreement.





shows that similar changes occurred concomitantly in the Southern Hemisphere.

A newer method involves the pollen grains given off by many flowering trees and plants. These are transported by the wind, as is well known by people with allergies, and collect in lakes and bogs and other places where they may become entombed in sedimentary formations. The pollen grains are amazingly tough and can survive for long periods in this environment, which is free of oxidation processes. A core sample of the sediments can be taken, and the distribution of pollen among the various species can be found by microscopic examination. In addition, the absolute rate of fall can be deduced if the sediments can be dated, perhaps by the well-known carbon-14 technique. The way in which the pollen distribution has changed as a function of depth in the core sample gives a measure of the local climate as a function of time. For example, as the ice melted beginning about 15,000 years ago in New England, tundra gave way to spruce, then to pine, oak, and chestnut. By studying such changes in vegetation, it is possible to make some deductions about temperature changes, with estimates for Europe in the 10-15°C. range—although vegetation could also change with precipitation, which complicates this method.

Carl Heusser of the Department of Biology at New York University has examined pollen samples from the Olympic Mountains in Washington and from the southern Andes in Chile, and deduced summer temperature changes of 6-7°C. for both regions for the last glacial maximum. The same technique has been applied by Linda Florer, also of New York University, to ocean core samples retrieved from the continental margin of the northwest Pacific, and pollen distributions have been obtained back to more than 300,000 years ago. (Dating is harder beyond the 50,000 years possible by the carbon-14 technique, although there are other radioactive clocks that may be used for ocean cores.) These pollen are thought to have been carried to the ocean by rivers, although doubtless some were airborne.

The distribution of fossil beetles is another useful guide in the construction of ancient temperature patterns for middle latitude regions. The beetles can run and fly considerable distances and can follow temperature changes quite rapidly—usually faster than the plant life. Many of the beetles complete their life cycle in the summer months while hibernating in winter, so are good indicators of mean summer temperature. Once again, it is the distribution between species that is monitored and compared with present-day distributions at different places. G. Russell Coope of the University of Birmingham has made a special study of fossil beetles, and finds that species found in England during the last glaciation correspond to those now found in northern Norway and Siberia. He deduces an ancient English climate with July mean temperatures lower by about 6°C. and even greater depressions in winter. While one might suspect that a small animal like the beetle may be subject to evolutionary changes, Coope points out that of 700 species so far recognized from fossil fragments, only about five are now extinct.

Planktonic foraminifera, radiolaria, and other microscopic organisms dwell in the surface layers of the ocean, and their species distribution varies with water temperature and salinity. When they die, they sink to the bottom, and their distribution is impressed in the ocean sediments, which are laid down at a typical rate of two centimeters per thousand years. Cores from the ocean bottom, typically 20 meters long, have been used to study the changes in the distribution as a function of time. From the distributions in the top portions of the cores and present-day measurements of surface-layer temperature and salinity, a relationship is set up enabling the distributions further down in the core to be interpreted in terms of temperature at past times. Time is followed through assumptions about sedimentation rate coupled with various check points provided by radioactive dating and other techniques. General findings about the distributions and their interpretations in terms of water temperatures have been known and exploited since 1910, but a quantitative approach that matches the distribution of species with the environmental parameters has been pioneered only recently by John Imbrie and Nilva Kipp at Brown University, who applied it to planktonic foraminifera. The Brown group, working in conjunction with others at the Lamont-Doherty Geological Observatory of Columbia University, the U.S. Naval Hydrographic Office, and several other groups under the National Science Foundation CLIMAP (Climate, Long-range Investigation, Mapping and Prediction) program, has constructed isotherms of the North Atlantic of 18,000 years ago, which show the Gulf Stream much farther south and without its characteristic northeastward flow—in fact it flows more or less due east. Temperature changes of 10°C. or more are indicated in the North Atlantic south of the ice shelves.

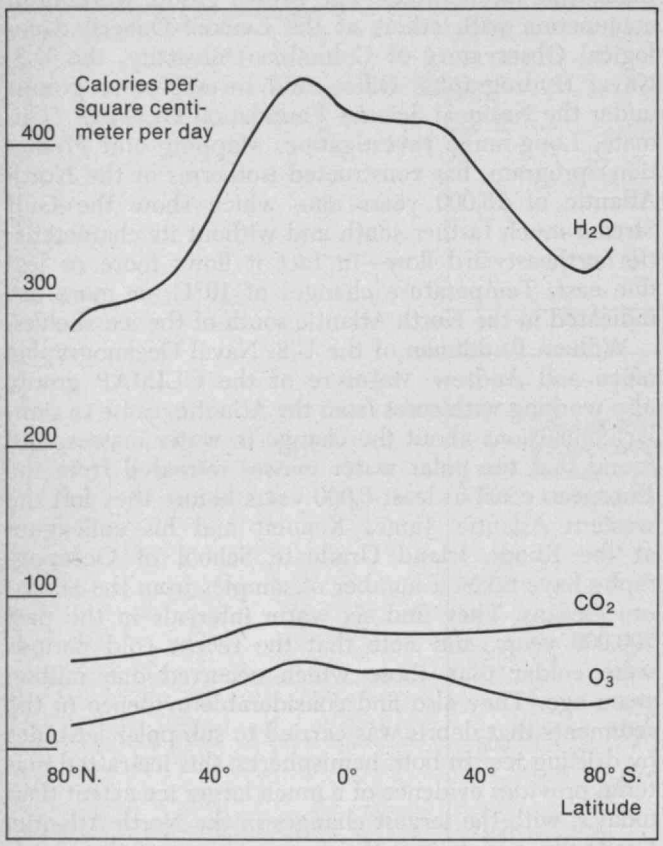
William Ruddiman of the U.S. Naval Oceanographic office and Andrew McIntyre of the CLIMAP group, also working with cores from the Atlantic, came to similar conclusions about the change in water masses, and found that the polar water masses retreated from the European coast at least 6,000 years before they left the western Atlantic. James Kennett and his colleagues at the Rhode Island Graduate School of Oceanography have taken a number of samples from the Southern Oceans. They find six warm intervals in the past 700,000 years, and note that the recent cold periods were colder than those which occurred one million years ago. They also find considerable evidence in the sediments that debris was carried to sub-polar latitudes by drifting ice. In both hemispheres, this ice-rafted material provides evidence of a much larger ice extent than today's, with the largest changes in the North Atlantic. Gradually, a picture of the ocean currents of the past is being built up, but so far most emphasis has been on the surface layers, with techniques applicable to the deep ocean only in their development stage.

Modern techniques have been used to monitor the oxygen isotopes O^{18} and O^{16} in glacial ice, forminifera, and sea water. Cesare Emiliani of the University of Miami was the first to apply these techniques extensively to the shells of foraminifera retrieved from ocean cores. The isotope ratio in the calcium carbonate which makes up the shell depends upon the water temperature and upon the isotope ratio in the sea water itself. Initially it was thought that the water-temperature effect predominates, but it is now believed that the oxygen-isotope ratio in the shells is governed primarily by changes in the sea water ratio. These changes come

about because ice deposited on land is rich in the lighter isotope, as shown from measurements by Willi Dansgaard of the University of Copenhagen and his collaborators at the U.S. Army Cold Regions Laboratory in New Hampshire on ice cores from Greenland and Antarctica. This leaves surface sea water enriched in the heavier isotope. Hence the isotope ratios in the shells really reflect ocean volume changes, as argued by Eric Olausson of the University of Göteborg and Nicholas Shackleton of the University of Cambridge, and are therefore a valuable indicator of glacial/interglacial changes.

Moreover, at colder temperatures, ice contains more of the light isotope. By using the present relationship between temperature and the isotope ratio, one can deduce polar temperature changes during the Ice Age from measurements made on fossil ice. Equivalent temperatures over Greenland were calculated by this method to have been up to 20°C. colder than today, and over Antarctica up to 13°C. colder. These estimates are upper limits because ice will have formed at progressively higher altitudes as the glaciers grew, so the natural decrease of temperature with altitude will be included in the results. The dating of the ice core material is a difficult problem that is not yet completely solved. The present time scales depend crucially on the assumptions made about the flow of ice through the glacial systems.

One other aspect of the foraminifera isotope records is their indication that the cold periods took a long time to develop and a much shorter time to disappear. There is a wide field of unfinished research on environmental oxygen isotope ratios and there is potential application to shorter time periods; recently A. T. Wilson in New Zealand pioneered a similar approach to the oxygen isotope ratios in stalagmites and hopes to obtain information on temperatures of the past, while Leona Libby in California has proposed that the oxygen, carbon, and hydrogen isotope ratios in tree ring material can be interpreted in terms of past temperatures.



The atmosphere's loss of energy to space is divided into three components, each representing the activity of a different molecule: water vapor (top line), carbon dioxide (middle line), and ozone (bottom line). The bonds between atoms in a molecule can be thought of as springs connecting a set of weights. If such a collection of masses is oscillated, there will be certain frequencies at which a given spring will vibrate most efficiently. Similarly, certain frequencies will most efficiently set a molecular bond to vibrating, or set the entire molecule rotating, and the molecule will selectively absorb and sooner or later re-emit these frequencies. In the atmosphere, only the triatomic molecules shown have significant absorption bands in the frequency region of the earth's radiation to space, so the presence of these molecules affects the atmosphere's capacity to retain energy lost from the earth's surface. Without the presence of these molecules, the energy would be lost far more rapidly. The chart was drawn using data for the month of January (Dopplick, 1970).

Theories of the Ice Ages

Every year we see the gradual buildup of ice in the Northern Hemisphere and we can record a temperature drop over the ice sheet. We have before us in microcosm all the ingredients of an interglacial-glacial change. If we examine why this happens, we see fairly clearly that each winter the Northern Hemisphere polar regions lose more energy than they gain: The basic energy source for the whole atmosphere is, of course, the sun, and its incident energy is spread over a large area at high latitudes, and does not reach latitudes north of the Arctic Circle at all in the deep of winter.

In any atmospheric column between the surface and, say, 30 kilometers there are several items in the energy balance that act together to control air temperature. There is the incident solar energy itself. Some is reflected by clouds or by the surface, the latter to a greater degree over ice than over land. The rest is mostly deposited at the surface, which in turn loses infrared energy, of which a part is absorbed and reemitted by the overlying air. Energy is also communicated from the surface to the air by conduction and convection processes. In addition, energy can be gained by the column of air if rain or snow falls from it. As water vapor condenses or freezes, so-called "latent" heat is given to the air, its ultimate source being the solar energy that was required to evaporate the water at the surface, often several thousand kilometers distant. Finally, large-scale motions of the atmosphere can contribute to temperature change by carrying warm air from low latitudes to high latitudes.

There is a continuous adjustment or near-balance among these processes as the solar angle changes throughout the year. Thus, as the solar elevation angle decreases in winter at high latitudes and the lower layers of the column cool, the increase in the equator-to-pole temperature gradient itself gives rise to stronger north-south motions of air that act toward reducing the gradient. The ocean, too, carries energy poleward with warm currents like the Gulf Stream and Kuroshio flowing north and cold currents like the Labrador flowing south. Furthermore, the ocean flows slowly, and because of its immense thermal capacity

is able to effectively store heat, so its presence introduces a time delay into the energy budget. Energy being supplied from the water to the air in the Norwegian Sea in winter may have been captured from the sun at much lower latitudes the previous summer.

For an interpretation of the earth's climatic history we should like to know the factors that create an imbalance in the earth's energy budget. Basically what happened to that budget during the last Ice Age was that an additional 47 million cubic kilometers of ice formed in polar regions, most of it in the Northern Hemisphere, but the latent heat liberated during these snowstorms was radiated away without compensation by an energy flux from lower latitudes.

Theories of the origin of Ice Ages rise and fall with the appearance and disappearance of persuasive scientists, the discovery of new facts, and the impetus given to the field by socio-economic events. Three general categories of theories may be distinguished: those which ascribe temperature changes to variability in the sun's energy output; those which blame regular variations in the orbital parameters of the earth, such as the sun-earth distance; and those which favor internal changes in the atmosphere-ocean-land system.

The first type of theory is somewhat suspect, because solar radiation in the visible region has been monitored for about 70 years and no significant variations have been found. The changes measured at the ground could all be accounted for by changes in the particle content of the atmosphere, a factor which increases substantially after large volcanic eruptions as sulphate aerosols form in the 15-25 kilometer layer. At very short wavelengths, solar electromagnetic radiation is highly variable, and in the 1-10 Angstrom range the changes often span orders of magnitude as solar flares grow and influence the solar atmosphere. But these wavelengths are all absorbed at high levels in the earth's atmosphere, typically above 80 kilometers, and although they induce profound alterations there, the energy involved does not seem large enough to affect the bulkier lower atmosphere.

The sun also emits corpuscular radiation which includes a background of "solar wind" containing protons of several thousand electron volt energy as well as the protons of much higher energy that are emitted from flares. Thus when the sun is very active (as judged by the number and size of visible spots on its surface), the corpuscular radiation output changes. In fact, there are variations in the carbon-14 content of organic matter with the 11-year sunspot cycle, brought about because solar corpuscular radiation deflects some of the cosmic ray radiation received at the earth that normally produces the neutrons that interact with atmospheric nitrogen to give carbon-14. Present sensitivities are such that the 11-year sunspot cycle can be seen in the carbon-14 content of wine and whisky. The carbon-14 content in the past has also varied, but we do not know how much of the change was due to solar variability, or to other factors, such as terrestrial magnetic field changes, which also govern the admission of cosmic rays to the earth's environment.

While the corpuscular solar emissions may vary, there is no evidence of concomitant variations in visible radiation, even with an 11-year cycle, and since it is the visible radiation that governs the circulation of the lower atmosphere, it seems reasonable to argue that

	Daily average				
	Dec.-Feb.	Mar.-May	June-Aug.	Sept.-Nov.	Annual
Northern hemisphere					
sensible heat	4.1	2.7	0.1	1.6	2.1
latent heat	3.3	2.9	2.6	2.9	2.9
ocean					3.3
Southern hemisphere					
sensible heat	−2.0	−2.2	−3.4	−2.5	−2.5
latent heat	−2.5	−2.7	−2.6	−2.5	−2.5
ocean					−4.4

The transport of energy across 30° North latitude (top) and 30° South latitude (bottom), in units of 10^{19} calories per day. That transport is from low latitudes, where more solar energy is incident than is radiated away to space, toward the poles, where more energy is lost to space than is immediately available from sunlight. Energy moves in three important ways: as "sensible heat," the motion of warm air toward the pole and cold air toward the equator; as "latent heat," carried toward the pole by water vapor, and freed when the vapor condenses or freezes; and in the ocean, by warm water moving toward the pole and cold water toward the equator. If an Ice Age is to begin at the poles, the energy flux from low latitudes must fail to replenish the deficit of energy there. To grow an extra 47 million cubic kilometers of ice over 8,000 years—as happened during the last Ice Age—the deficit in the energy budget would have to be about 1×10^{19} calories per day. (Only an annual figure is shown for the ocean's energy transport, due to the present lack of measurements of water temperature and flow at many locations and over long periods of time.)

the visible solar output has not been the controlling factor in glacial/interglacial changes over the past 200,000 years. There have been some recent measurements of solar ultraviolet output, however, which have shown significant time changes, so in order to settle the question satisfactorily it seems desirable to monitor the solar visible radiation from a satellite for long periods.

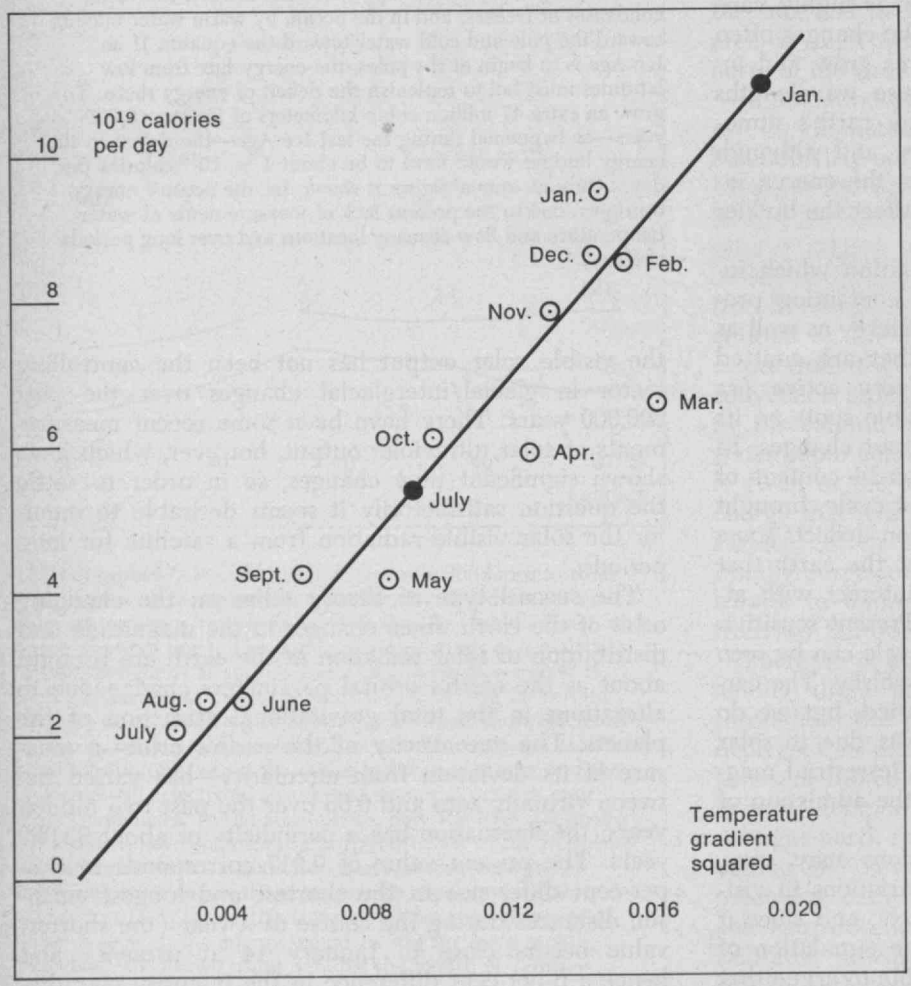
The second type of theory relies on the changing orbit of the earth, since changes in the magnitude and distribution of solar radiation at the earth are brought about as the earth's orbital parameters change due to alterations in the total gravitational attraction of the planets. The eccentricity of the earth's orbit—a measure of its deviation from circularity—has varied between virtually zero and 0.06 over the past two million years; the fluctuation has a periodicity of about 93,000 years. The present value of 0.017 corresponds to a 3-per-cent difference in the shortest and longest earth-sun distances during the course of a year (the shortest value occurs close to January 14 at present) and hence a 6-per-cent difference in the intensity of radia-

tion received. The angle between the earth's rotational axis and the earth's orbital plane varies between 22.0° and 24.5° with an average period of about 41,000 years. The rotational axis itself precesses about a normal to the earth's orbital plane with a period of about 26,000 years. M. Milankovitch in the 1920s and 1930s and A. Vernekar quite recently have computed the resulting values of radiation received at the top of the atmosphere as a function of latitude and time back to 2 million years ago. If the temperature, moisture, and infrared radiation conditions were also known, we could compute the net poleward energy fluxes and see if these orbital changes could account for the observed glacial/interglacial changes.

Another way to alter the temperature is to change the atmospheric transmission to radiation. There are several possibilities to be considered. Volcanoes inject large quantities of sulphur dioxide into the atmosphere and this evolves into a sulphate aerosol that absorbs solar energy at the 15-20 kilometer layer and prevents it from reaching the ground. Surface cooling is the net result. There is no evidence, however, of massive volcanic activity concentrated near the start of Ice Ages. Water vapor strongly influences infrared transmission, and its concentration in the atmosphere increases with temperature. As seen from the chart on page 34, it dominates the infrared radiation lost to space, in such a way that lower concentrations are associated with smaller infrared losses, although temperature is also a variable here. Carbon dioxide is another important absorbing gas, and its concentration, at least on time scales like the past 100,000 years, depends on oceanic temperatures, a cold ocean being capable of holding more carbon dioxide than a warm ocean. Many opportunities for feedback occur in these trace-gas effects, and we cannot at present rule out some type of instability in trace-gas concentrations as a contributor to glacial-interglacial changes.

The third category of Ice Age theories postulates some type of instability in the atmosphere-ocean energy budget, which may cause Ice Ages without the assistance of any of the effects we have described.

Basically, there is more solar short-wave radiation received at low latitudes in the summer than is radiated back to space in the infrared, whereas at high latitudes, particularly in winter, the infrared loss exceeds the short-wave radiation received. To balance the budget, there must be an energy transfer from low to high latitudes. At 30° latitude, there are three important terms in this energy transport, as shown in the table on page 35. We wish to know if any of these terms is susceptible to a type of positive feedback which would lead to an enhancement of a perturbation. The sensible heat flux—warm air being carried poleward and cold air equatorward—varies with the square of the pole-to-equator temperature gradient. Thus if the flux itself diminishes and the polar temperature goes down as a result, the gradient increases and a higher flux is established; the feedback is negative and there is a tendency toward stability. Present-day observations, together with gradients estimated from the techniques described earlier, provide a way to estimate sensible



An estimate of the poleward heat flux in the earth's winds during the height of the most recent Ice Age, 20,000 years ago. First, using recent data (Oort and Rasmusson, 1971), the flux is shown to be closely proportional to the square of the temperature gradient. The horizontal axis plots $((T_{20°}-T_{70°})/T_{45°})^2$—in words, the square of the difference between the temperatures at 20°N. and 70°N. divided by the temperature at 45°N. The open circles show monthly averages for January through December, and a line is drawn to fit that data. Then two closed circles are placed on the line by using temperature estimates for 20,000 years ago derived from a composite of sources, including fossil pollen and oceanic microorganisms, oxygen-isotope measurements in fossil ice, and snow-line estimates made from geological features. These temperature estimates thus are made to correspond to estimates of the atmospheric heat flux in winter and summer 20,000 years ago; and that flux is seen to be higher than the present range, in accord with the theory of Ice Ages shown on page 39 and discussed in the text.

heat flux in the past, as shown in the chart at the left.

The second component of the energy flux is that due to heat liberated by water vapor when it condenses or freezes. The feedback direction for this flux is not so clear cut; the flux itself depends on the deviation of moisture content in the atmosphere from typical values for a latitude, together with wind variations. The amount of moisture the air can hold is smaller at lower temperatures, and it is tempting to argue that because the moisture content would therefore be lower in an Ice Age, the transfer of latent heat energy would also be smaller. Yet because the significant moisture difference may have been concentrated over a narrower range of latitude as the ice caps moved south, it is not possible to argue that the gradients themselves were smaller in an Ice Age. Furthermore, the north-south wind velocity may have been larger in an Ice Age, as indications are that the entire atmospheric circulation was more energetic. Stronger winds would increase evaporation at low latitudes. Hence it is hard to argue in favor of either positive or negative feedback for the moisture flux. This conclusion, albeit unsatisfactory, is backed by the data of the table on page 35, for there is little change in moisture flux with season, and as we have noted, the seasonal change may be treated as a microcosm of the glacial/interglacial change.

The third important flux is that due to the ocean, and here we have the drawback that there are no reliable seasonal values for comparison, due largely to the difficulty of estimating the energy stored in the ocean. Energy enters the ocean from the sun at low latitudes and is absorbed in the top layer, which is about 100 meters thick. This top layer is maintained warm relative to the deeper ocean, but at high latitudes, water near the ice shelves (in an Antarctic region like the Weddell Sea or an Arctic one like the Norwegian Sea) cools by energy loss to the air. It thus becomes more dense and sinks to depths where the water is all cold—close to 1-2°C. on the bottom. From there, cold water spreads over the ocean floor and passes into the North Atlantic, the Indian, and the North Pacific Oceans. Now in the large ocean basins, the surface waters are accelerated by wind stress, and large circulating current systems called gyres are maintained. Off the coasts where winds blow offshore, the surface water is carried out to sea and is replaced by upwelling colder water—in essence, the surface skin is removed. A similar process acts along the equatorward region of the Pacific and Atlantic where easterly winds deflect the water northward in the Northern Hemisphere and southward in the Southern Hemisphere, leading to a divergent region also replaced by the upwelling of cold water from below. When the winds in these upwelling regions are stronger, surface water temperatures are likely to be lower. Thus, because we expect stronger winds during an Ice Age, due essentially to greater temperature gradients in middle latitudes, we would anticipate somewhat lower surface water temperature in the upwelling regions. Insofar as this water mixes with the warm surface skin and controls the heat carried poleward by the ocean, there is a potential here for a positive feedback of the coupled atmosphere-ocean system: If the oceanic flux diminishes, high latitudes, which depend partly on the ocean for their heat supply, may cool off. The atmospheric temperature gradient will increase, and with it the winds, so that there will be more cold water upwelling at low latitudes. Hence the poleward ocean flux will be further diminished. One would expect a higher atmospheric heat transport from the higher winds and therefore some compensation for the high-latitude deficit. But it is hard to argue that there is an exact balance even now (in fact the current best data, shown in the table on this page, do not show a balance) and we clearly need to refine our knowledge of the energy budget estimates for the ocean.

If there is a decreasing oceanic energy flux on a large time scale, we might expect a gradual buildup of ice caps and ice sheets, beginning at high latitudes. But such an Ice Age could automatically bring about its own end. Peter Weyl of the State University of New York has shown that the thickness of an ice sheet does not exceed more than about one meter. An ocean covered by this lid loses much less energy to the air than an open ocean does, so as the sheet advances, the region of cooling loss shifts equatorward. But this only proceeds until the balance of energy at the surface (see the table on this page) becomes a surplus south of about 40° latitude, and energy becomes available, particularly in the summer, to melt ice. Meanwhile, the production of cold water at high latitudes will have been substantially diminished by the ice sheet's insulating property. Moreover, there will be a gradual warming of the ocean at low latitudes, due to conduction of energy downward from the ocean's surface and up from the earth's interior. Therefore warm water will become extensive in the deep ocean, and eventually the upwelling water will also warm up. The ultimate consequence will be an increased poleward energy flux in the ocean while the ice caps melt back, which takes several thousand years. When the fossil evidence is assembled into a set of climatic patterns for several representative

Latitude	Calories per square centimeter per day	Latitude belt	Heating or cooling (10^{18} calories per day) Northern hemisphere	Heating or cooling (10^{18} calories per day) Southern hemisphere
0°	41	0°-10°	13.0	12.7
10°	35	10°-20°	7.6	8.0
20°	13	20°-30°	0.7	0.9
30°	− 6	30°-40°	− 1.6	− 2.4
40°	− 9	40°-50°	− 1.6	− 3.2
50°	−12	50°-60°	− 2.0	− 5.0
60°	−24	60°-70°	− 2.9	− 7.8
70°	−47	70°-80°	− 4.1	− 5.7
80°	−72	80°-90°	− 2.6	
90°	−82			

The heat budget at the surface of the ocean. A negative number signifies a deficit—in other words, that the surface of the sea loses heat to the atmosphere. A positive number signifies a surplus—the ocean surface gains heat from the sun, heat which can melt ice. Thus the latitude at which the sign changes from minus to plus approximates a line at which the advance of an ice sheet toward the equator would be arrested. The left two columns show the daily heat gain (+) or loss (−) for a square centimeter of ocean surface at a given latitude. The numbers are taken from Defant's *Physical Oceanography*. The right three columns, which rely on those numbers, show the total daily heating or cooling of the ocean surface by ten-degree latitude belts from pole to pole.

times in the past 100,000 years it will be possible to combine these with input radiation values synthesized by Vernekar for the earth's changing orbital conditions, and compute poleward energy fluxes to see if they vary according to the scheme outlined. But such work requires development of a better knowledge of the present oceanic circulation and energy budget, and that is only coming slowly.

Feedback processes abound in such a complex system. Often mentioned, particularly by Mikhail Budyko of the U.S.S.R., is the ice reflectivity feedback. More ice at high latitudes leads to less solar radiation available at the surface, because an open ocean has a typical reflectivity of 20 per cent whereas ice can range up to 80 per cent. The effect will be particularly powerful in the summer and could lead to maintenance of the ice through that season, further growth the next winter, and so on, rather than the melting back which we now see each summer. The initial growth of ice in such a sequence is often hypothesized to be triggered by a solar output decrease or by a period of high atmospheric dust loading. There are many more potential feedback processes, and they will probably be best studied by a computer model, as we shall mention later. Development of such a model involving complex feedbacks is a challenge that will almost certainly lead to a better understanding of the system in its present state.

The Climate of the Distant Past

As we look back beyond several million years, the picture of the earth's climatic history becomes more blurred as the evidence becomes less abundant and the number of variable physical factors increases. In fact, one major variable is the geographic distribution of the continents and oceans. The earth's crust and upper mantle are thought to be divided into a few large pieces called plates, which have a relative motion such that the continents are moving apart at a rate of a few centimeters per year. Most of these blocks are thought to have been clustered into a single large continent, Pangaea, some 250 million years ago. Before that time, there may have been more than one continent. Since that time, South America has drifted away from Africa, and North America from Europe, and Africa has moved steadily northward.

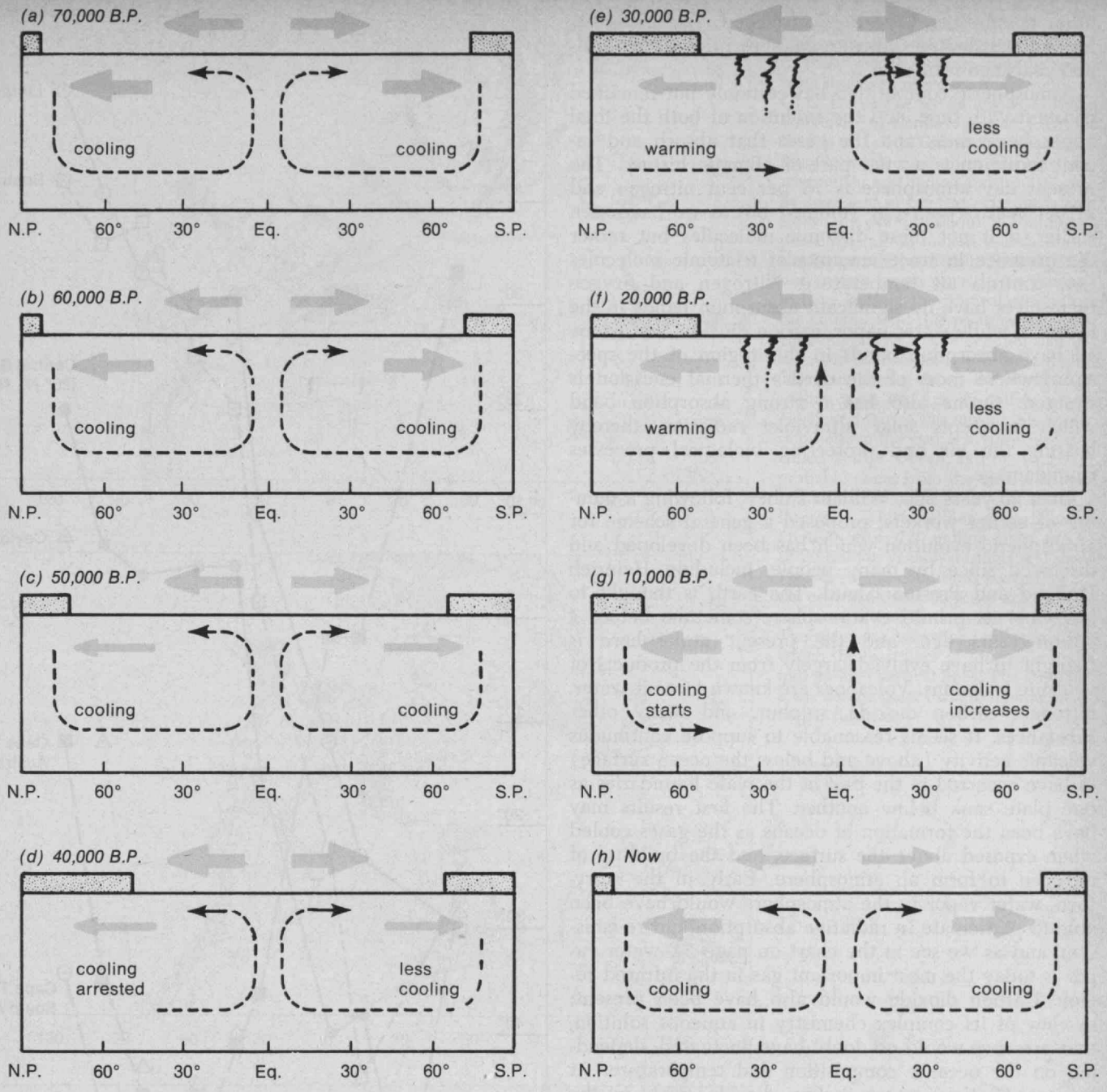
The Atlantic Ocean floor is mostly new material brought up from below in the last 200 million years. As the new material comes up in molten form and then solidifies, the local magnetic field at that time is frozen into the rock. Thus, as the plates move and the rock is carried to different latitudes, it takes with it a record of the latitude at which it solidified, and from rock samples spaced over the globe, it is possible to trace backward in time the movements of the crustal surface layers. Reconstructions made mainly in this way have been checked at several points by radioactive-isotope observations which can be used to match rock types on separated continents.

There is an intimate relationship between the motion of the continents and the climate of the past, and in fact climatic interpretations provided some strong evidence for continental drift some fifty years ago. Basically, we may regard the variation of climate with latitude as fixed by the earth's spherical geometry, the atmospheric composition, and the solar radiation. There is a region of rising air motion at low latitudes, part of the "Hadley Cell" circulation, where rainfall is abundant; there is descending air motion in the subtropics, which gives rise to clear areas over the oceans and encourages deserts over the land; and there are further belts of rain produced by the ever-changing eddy disturbances of middle latitudes. The details of this circulation scheme do vary with longitude, depending on the distribution of land and sea, but the broad outline does not. Hence, as a continent such as Africa moves from the Southern Hemisphere to the Northern Hemisphere, its northern limit will experience first tropical rain, then aridity, and then middle-latitude type rain.

Alfred Wegener, in his pioneering work on continental drift 50 years ago, pointed out that in the Carboniferous Period about 340 million years ago, England and eastern North America were in the tropical rain belt with their rich flora fed by the strong sunshine and moisture supply, and he suggested that coal formed because of these conditions. A glance at the reconstructions recently made by A. G. Smith and G. E. Drewry of Cambridge University and J. C. Briden of Leeds University shows that northwest Africa was subsequently in the same favorable position, and one might expect coal formation in the western Mediterranean some 250 million years ago. Thirty million years later, when northern Saudi Arabia, northern Egypt, and the central Sahara were at the right latitude, the broad pattern was similar: there was still an extensive ocean area to the east, and the winds were easterly (the situation was somewhat similar to that in the Amazon Basin today). Have these desert regions been extensively explored for coal? Or did the flora change with time? We also note from these reconstructions that while London was crossing the tropics, Cape Town was probably suffering severe glaciation at the South Pole—another point stressed by Wegener.

An assumption behind these reconstructions is that the magnetic poles are coincident with the geographic poles. This is not true at present, and relative displacement between these poles may account for the jerkiness of the motions shown in the chart on page 40. Data on flora and climate may eventually be used to refine the reconstructions, just as they were used earlier to support ideas of continental drift.

Another factor that enters into changes on this enormous time scale is the variability of the spin rate of the earth. Nature has provided a convenient record of this spin rate in the growth of corals. The calcium carbonate deposition is greater during sunlight than darkness, resulting in the formation of layers, one for each day. The growth is also modulated by the seasonal change in solar angle and intensity, and thus the number of days in a year can be estimated from the number of thin layers within one cycle of the broader modulation. There were about 405 days in the year some 400 million years ago, so the earth was rotating about 10 per cent faster than now, corresponding to a length of day of about 21½ hours. From what we know about the dynamics of the circulation, it is reasonable to expect that the middle latitude storm belts were even more active than today, and consequently that the overall wind strengths were greater. The factor responsible for the recent slowing of the earth is thought to be tidal friction due mainly to the moon, but



A very schematic view of the theory of Ice Age origin proposed by the author. The changing sizes of the grey arrows suggest the changing magnitudes of poleward energy fluxes in the atmosphere and oceans as the ice sheets (stippling) advanced and retreated. A central assumption of the theory is that the energy deficit near the poles is not quite balanced by energy arriving from lower latitudes. In that case, surface water near the poles was cooling, sinking, and spreading over the ocean bottom 70,000 years before the present, or B.P. The global ocean circulation brought this water to low latitudes, where it upwelled and turned poleward (a). The result of such a feedback loop was to further reduce the poleward oceanic energy flux (b), further imbalance the polar regions, and cause the formation of excess ice (c). As it advanced toward the equator, this ice placed a lid on the ocean, one whose insulating property prevented heat loss from the surface water and thus began to arrest the cycle of cooling (d). At middle and low latitudes, the diminution of the cold-water supply permitted a gradual warming of the deep ocean by heat conduction downward from the surface layers. Meanwhile, the progress of the ice sheet itself was arrested when it reached latitudes at which there is a surplus of energy at the surface (e). Here, incident solar radiation provided more energy than was radiated to space, and this surplus melted the ice, particularly in summer months. These two factors combined to end the Ice Age (f and g) far more rapidly than it began, in part because the onset relied largely on oceanic transport of energy, while the conclusion could be hastened by the atmosphere's energy transport, which would increase during the Ice Age because the increasing temperature gradient would increase the winds. In cell (g), depicting presumed conditions of 10,000 years ago, the Ice Age has ended. The ice sheet has retreated, and the temperature gradient is smaller, so wind strength has decreased. But the presumed polar imbalance in the energy budget is at work again. Surface water in polar seas is growing cooler, in the slow process that will lead to the next Ice Age. Cell (h) may represent present conditions.

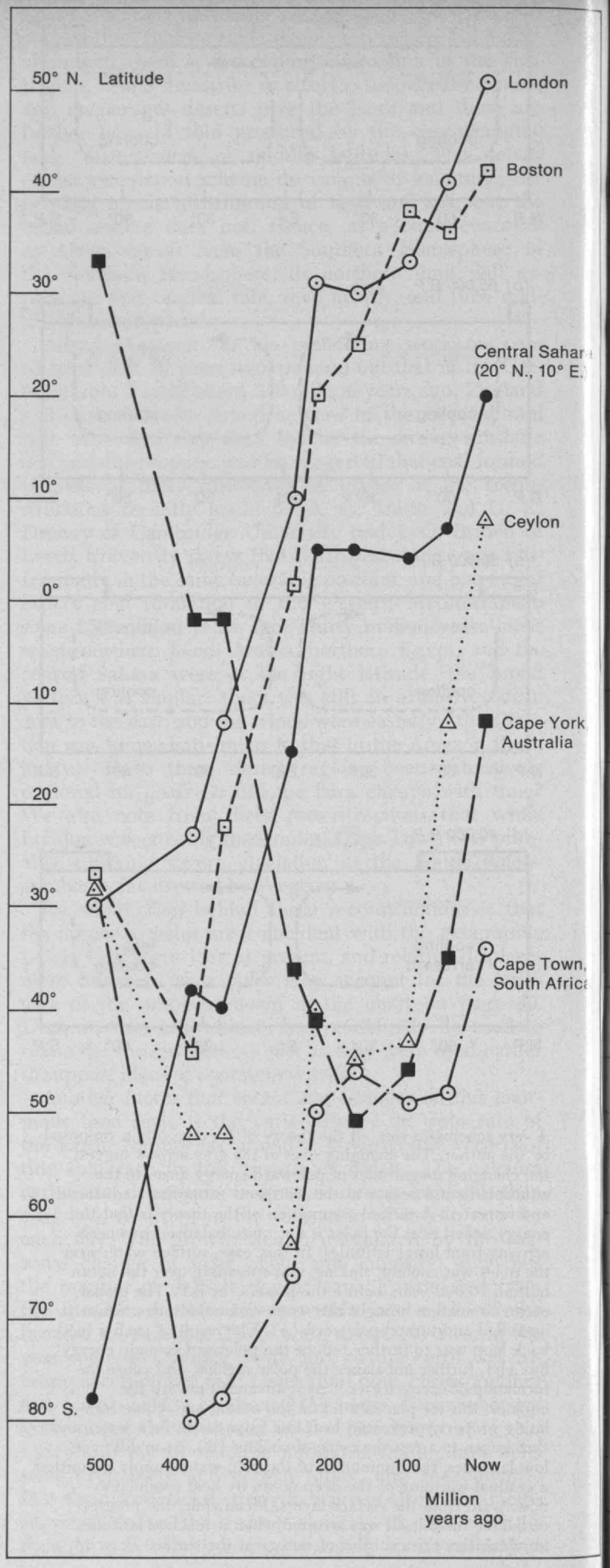
Present-day measurements of the energy flux in the ocean are not sufficient to determine reliably whether there actually is an oceanic imbalance at the poles. It happens that the data from the table on page 37 do show an imbalance, but it is opposite to the one required here. The important point is that, considering the oceanic part of the earth's energy budget alone, there is no obvious physical reason to demand an energy balance.

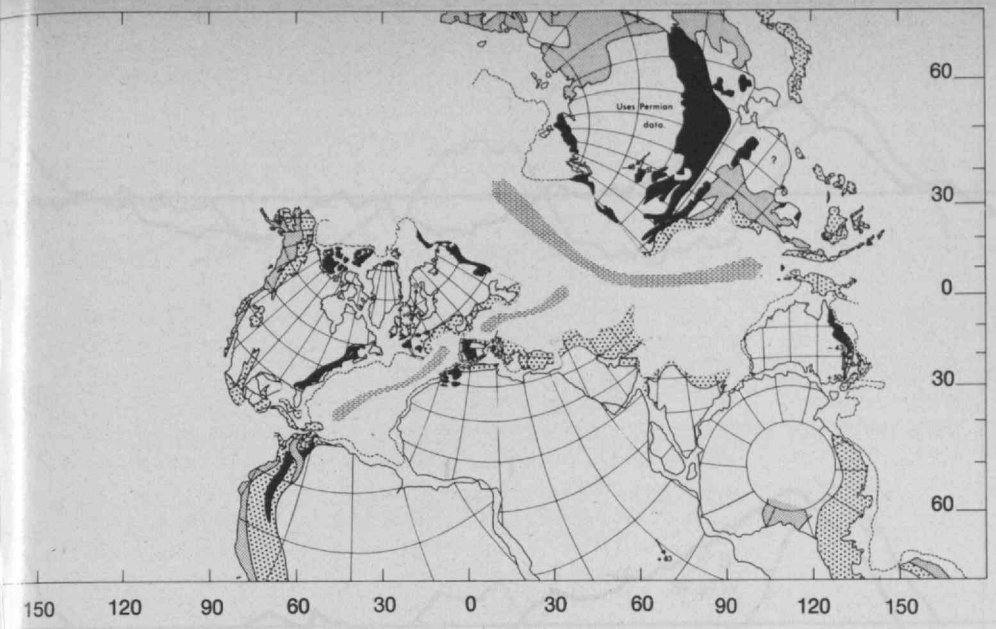
other possibilities have been discussed. The prospects for examination of spin rate changes prior to 500 million years ago seem slim.

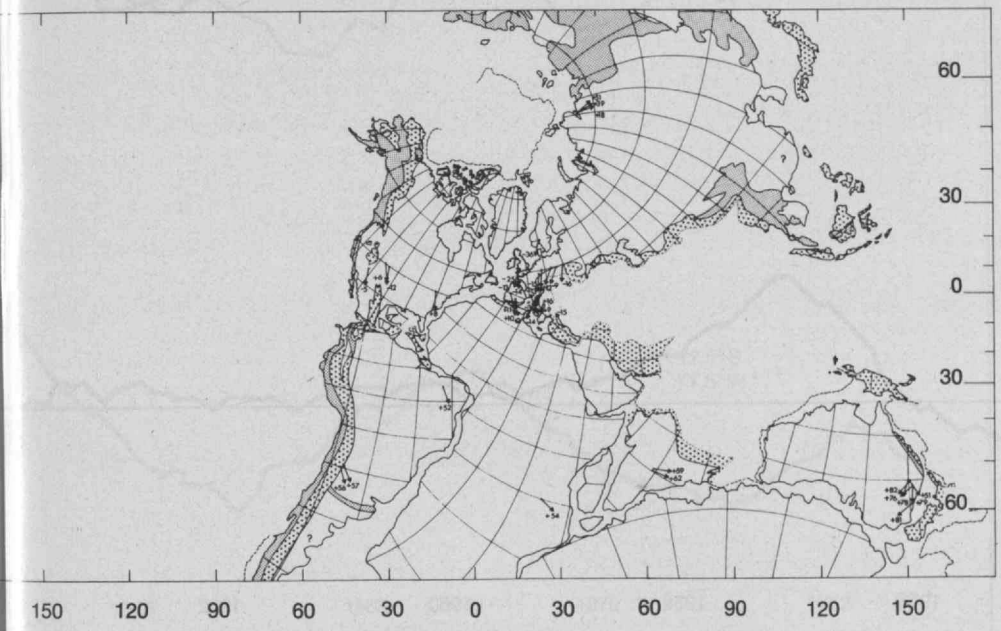
Atmospheric composition has certainly not remained constant with time, and the evolution of both the total atmospheric mass and the gases that absorb and re-emit radiation is a vital part of climatic history. The present day atmosphere is 78 per cent nitrogen and 21 per cent oxygen (by volume) but as we have seen earlier, it is not these diatomic molecules but rather the presence in trace amounts of triatomic molecules that controls air temperature. Nitrogen and oxygen themselves have no significant absorption bands in the infrared, while water vapor, carbon dioxide, and ozone all have absorption bands in this region of the spectrum, where most of the earth's thermal emission is situated. Ozone also has a strong absorption band which intercepts solar ultraviolet radiation, thereby heating the air and protecting biological processes from damage.

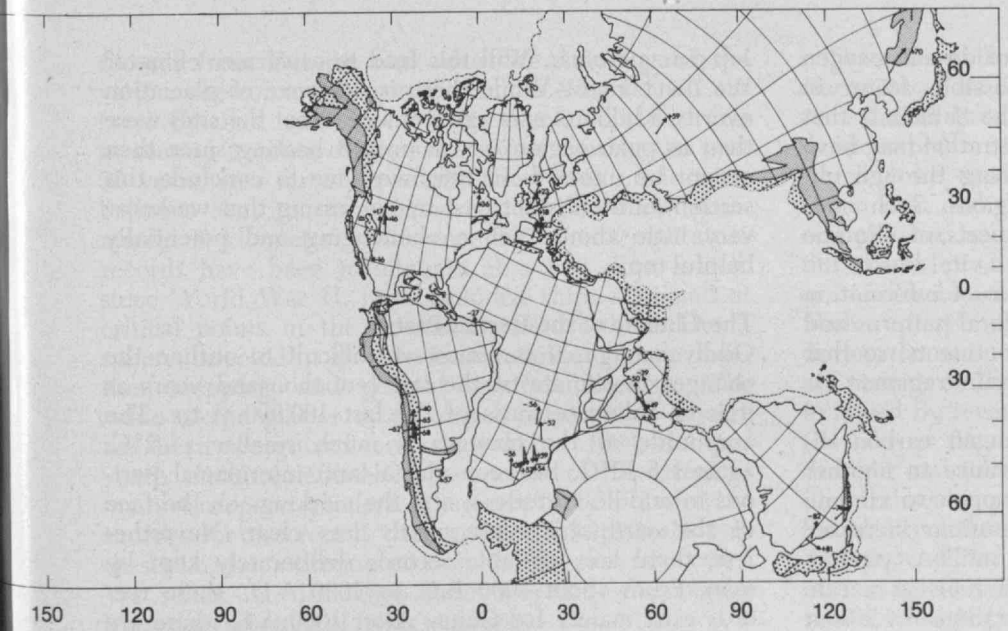
Over 20 years ago, William Rubey, following a number of earlier workers, proposed a general scheme for atmospheric evolution which has been developed and discussed since by many people, including Heinrich Holland and Preston Cloud. The earth is thought to have lost its primitive atmosphere sometime before 4 billion years ago, and the present atmosphere is thought to have evolved largely from the products of volcanic emissions. Volcanoes are known to emit water, nitrogen, carbon dioxide, sulphur, and many other substances. It seems reasonable to suppose continuous volcanic activity (above and below the ocean surface) to have occurred in the past at the plate boundaries as one plate sank below another. The first results may have been the formation of oceans as the gases cooled when exposed above the surface, and the build-up of nitrogen to form an atmosphere. Early in the story, then, water vapor in the atmosphere would have been able to participate in radiative absorption and re-emission, and as we see in the chart on page 34, water vapor is today the most important gas in the infrared region. Carbon dioxide would also have been present; in view of its complex chemistry in aqueous solution, that presence would no doubt have fluctuated, depending on the oceanic composition and temperature. At present, 60 times more carbon dioxide exists in the ocean than in the air.

The atmospheric content of oxygen is thought to have been derived from carbon dioxide and water vapor. Photosynthesis and plant life processes are the candidates for oxygen production from carbon dioxide, with the carbon ultimately being laid down in the sediments at the ocean floor while the oxygen remains in the air and ocean. The other possible contribution is the light-induced dissociation of water vapor in the upper atmosphere, with the subsequent loss of hydrogen to space, since its thermal energy exceeds the gravitation holding the gas to the earth when the upper atmosphere becomes heated by an active sun. Whichever source predominated, once oxygen achieved a significant concentration, ozone would have appeared, too, and the surface layers would have been sheltered from harsh ultraviolet radiation and hence made available for life processes to flourish. Present estimates place this critical step at about 2 billion years ago. Since then, there has probably been a steady buildup of ni-



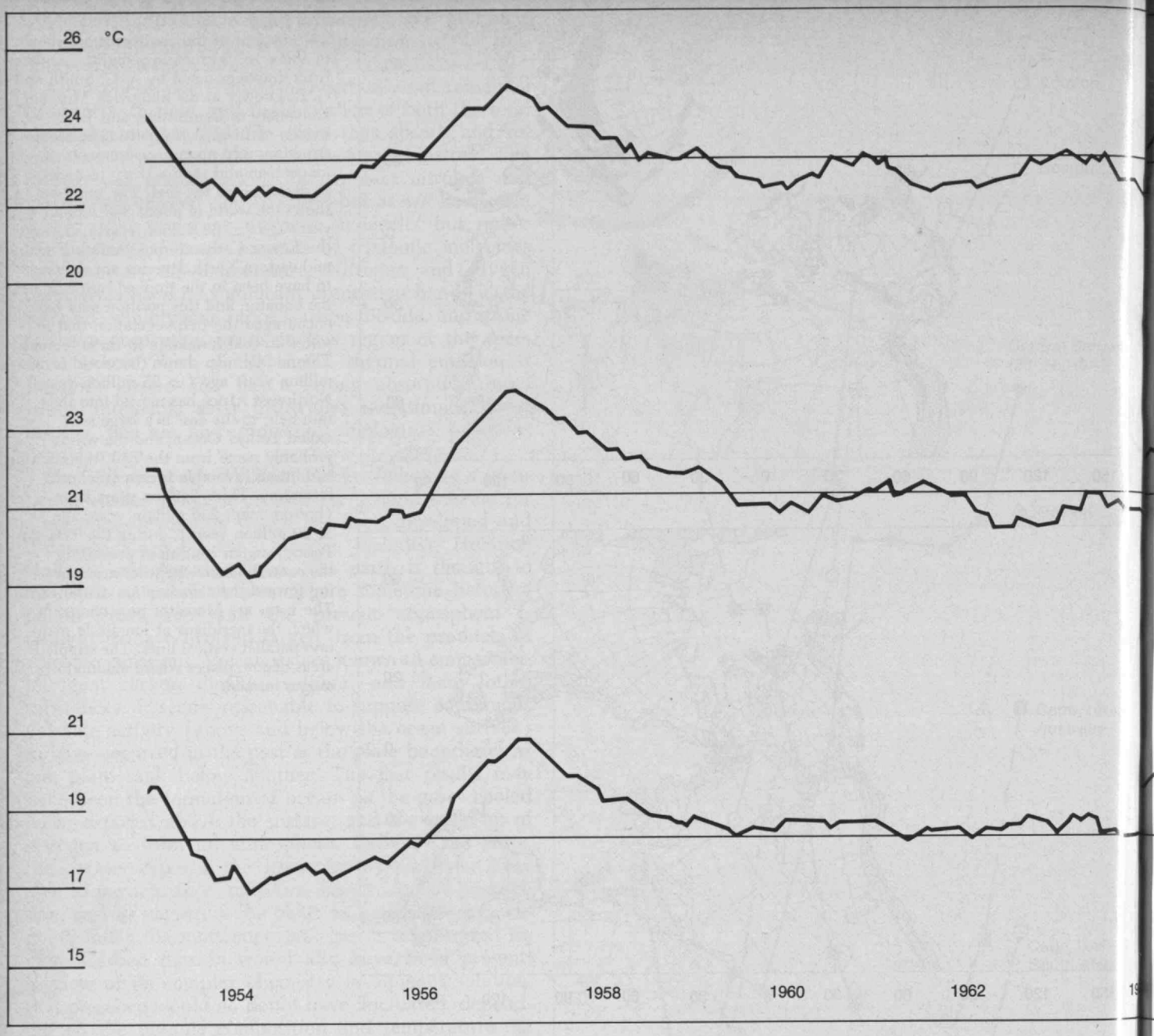






This page:
The motions of the continents are shown in these reconstructions, slightly modified from drawings made by A. G. Smith and G. E. Drewry at the Sedgwick Museum, University of Cambridge, and J. C. Briden of Leeds University. The reconstructions rely upon measurements of magnetism and radioactivity in rocks, as described in the text. The top map shows the world of about 340 million years ago (± 30 million years), during the Lower Carboniferous Period. England and eastern North America are shown to have been in the tropical rain belt near the equator, and this position may have encouraged the rich vegetation that resulted in coal formation in these regions. The middle map shows the world of 250 million years ago (± 25 million years). Northwest Africa has moved into the rain belt; to the east is a large sea called Tethys' Ocean, and the winds probably come from the east, maintaining conditions favorable for eventual coal formation. Thirty million years later (bottom map; 220 million years ago, ± 20 million years), during the Triassic Period, similar conditions prevail for the central Sahara. Reptiles are evolving toward their domination of the earth. The maps are Mercator projections, in which the meridians of longitude map into parallel vertical lines. The stippled areas denote places where mountain ranges formed.

Opposite page:
The changing latitude of six places on the earth's surface, based on reconstructions made by A. G. Smith and colleagues, of which three are shown on this page. The chart supports arguments made by Alfred Wegener a half-century ago. Wegener proposed that England was in a rain belt near the equator 340 million years ago, while southern Africa was near the south pole. The central Sahara moved into that rain belt 120 million years later, raising the question of whether coal formed there for the same reasons it had formed in England.

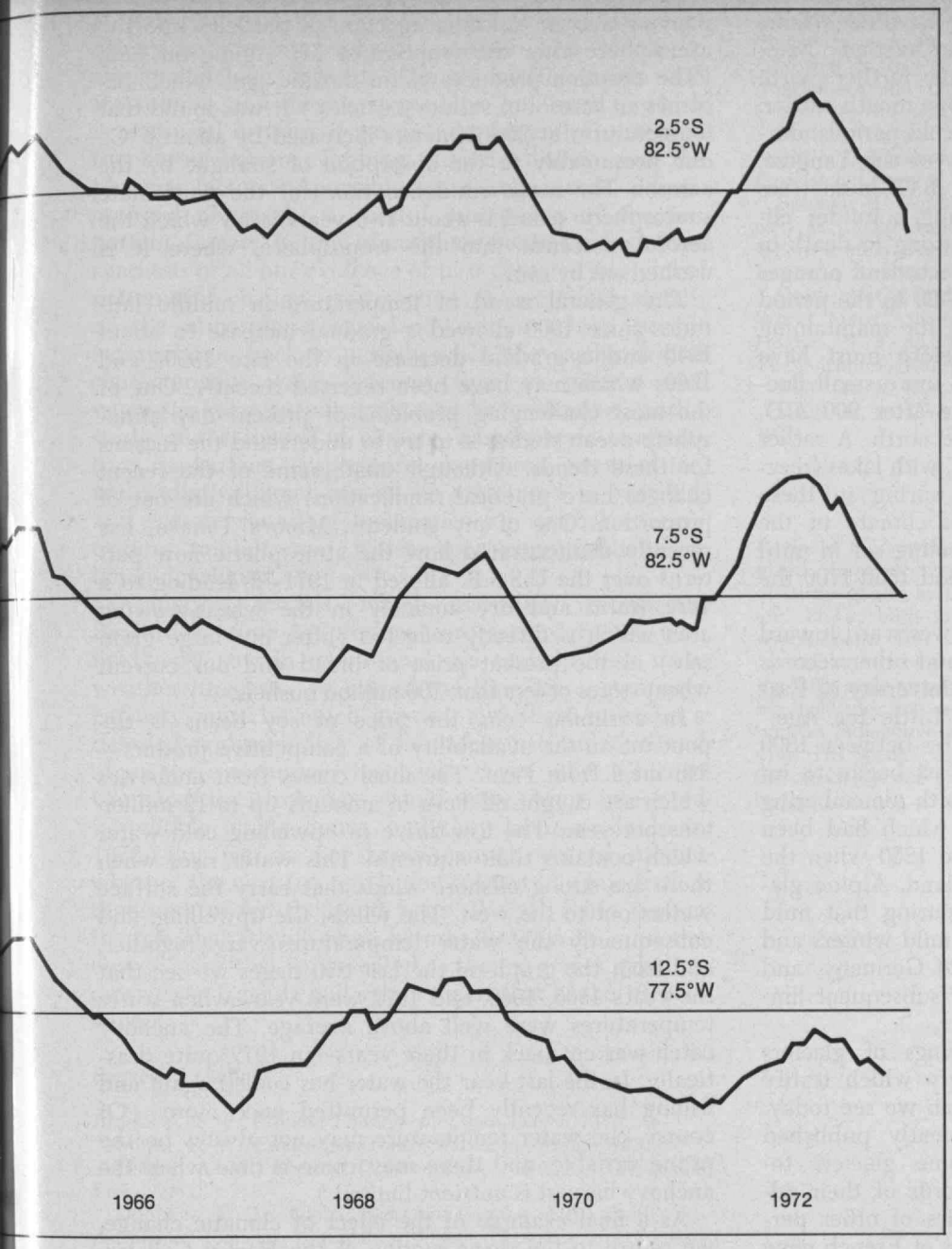


trogen, with fluctuations of carbon dioxide and oxygen superimposed. Therefore, another possible factor in our earlier discussion about coal in the Sahara is that the atmospheric carbon dioxide concentration may have been low while that region was passing through climatologically favorable equatorial regions. Such matters focus on the interdisciplinary aspects of climatic history interpretation and also provide a vital link to the modern energy crisis. Can we reconstruct information about carbon-dioxide concentrations, floral patterns and evolution, and the positions of the continents, so that we may look harder for coal in certain regions? Or estimate the earth's total coal reserves?

The climatic consequences of changed carbon dioxide concentrations are also of relevance to another contemporary problem: What will happen to climate in the next hundred years as concentrations increase? At present, with CO_2 at 320 parts per million (p.p.m.) by volume, we are burning up fossil fuels at a rate which increases atmospheric concentrations by about 1 p.p.m. per year. Will this lead to a warmer climate? We don't know. While there is evidence of glaciation over two billion years ago it may be that the sites were then in polar regions so an overall heating since then cannot be inferred. In fact, we have to conclude this section on the distant past by confessing that we know very little about such a challenging and potentially helpful topic.

The Climate of the Recent Past

Oddly enough, it is almost as difficult to outline the changes in climate of the last few thousand years as it is to delineate those of the last 100,000 years. The amplitude of the changes is much smaller (1-2°C. against 8-10°C. between glacial and interglacial periods in middle latitudes), and the markings on the face of the earth are consequently less clear. Nevertheless, there are available records deliberately kept by man. From about 3000 B.C. to 1000 A.D., these records exist mainly for China. After 1000 A.D. there are



The mean temperature of the ocean surface at three places in the anchovy fishery off the coast of Peru. The annual catch increased throughout the 1960s, reaching a peak of 12.3 million tons in 1970. But it dropped by about 2 million tons in 1965 and in 1969, and by more than 5 million tons in 1972. The chart shows that the ocean surface was warmer than usual in those years—an unfavorable circumstance for anchovies, which rely on nutrients that rise with cold water from the deep ocean where the offshore winds are of sufficient strength to displace the warm surface water.

records from Europe, and since the founding of the various meteorological services in the Nineteenth Century, detailed records have been maintained at an increasing number of ground stations. During the past 30 years, free air observations have been made from balloons sent to ever increasing heights—now commonly 30 kilometers. And since 1900 sea temperature records have been maintained at a few sites, which, since World War II, have included ships stationed at critical points in the oceans of the Northern Hemisphere, selected to give the best possible help for aviation, shipping, and general weather forecasts. The value of the glacier as an overall measure of climate has been recognized, and since about 1880, detailed yearly measurements have been made of the extent of many European glaciers. There are thus a variety of sources for the recent data, although large-scale synthesis has been attempted only in the past few years. We select for discussion here only a few examples from the vast store of items available.

The earliest Chinese records have recently been summarized by Chu Ko-Chen of the Academia Sinica. They were culled from a study of oracle bones—the broad shoulder-blades of cattle and the shells of tortoises, which were used as a means of communication between men and the gods. Oracle bones were flattened and polished and touched with a glowing bronze rod, the cracks produced being interpreted as favorable or unfavorable answers to a question asked of the gods. Such a question might have involved a forecast of rain during the season prior to harvest. For example, there are records of "favorable oracles for the next ten days" followed by records that it did indeed rain in the next few days, thus verifying the forecast. Apparently, drought and its effect on the harvest was dreaded: In one archaeological site, over 100,000 such bones were found. From these finds, the variation of the crops with latitude and date can be surmised, or sometimes the occurrence of rain as opposed to snow. And thus a picture of changing climate is developed.

The period 3000-1100 B.C. seems to have been some 2°C. warmer than now in the annual average. Bamboo was found some 3° of latitude farther north than now, and rice was sown almost one month earlier. At about 900 B.C. there were several cold periods, during which the Han River, a tributary of the Yangtze, froze. Then in the period up to 500 B.C. plum trees spread all over the country, indicating a milder climate. There are records of people freezing to death in the period 200-100 B.C., followed by records of oranges growing in the royal gardens at 100 A.D. In the period around 500 A.D., ice houses existed for maintaining food fresh at Nanking, which therefore must have been colder than today. After several more small fluctuations, climate began to deteriorate after 900 A.D. and the plum tree disappeared in the north. A rather sharp cooling occurred after 1100 A.D., with lakes freezing and snow persisting until late spring in these years. There was an amelioration of climate in the period 1200-1250, but then further cooling set in until the Nineteenth Century, with the period 1650-1700 the coldest of all.

The cold anomalies seemed to shift westward toward Europe, for it is there in the glacial and other records summarized by Hubert Lamb of the University of East Anglia that we find evidence for a "Little Ice Age," marked by particularly low temperatures between 1300 and 1750 A.D. Ice off the Iceland coast began to increase at about 1200 A.D., and it is worth remembering that there were farms in Greenland which had been started in the mild period from 750 to 1200 when the Vikings colonized Greenland and Iceland. Alpine glaciers had shrunk back considerably during that mild period, and records of that time show mild winters and dry summers in England, France, and Germany, and fossil forests in Canada north of their subsequent limits.

There are many beautiful engravings of glaciers made in the early Eighteenth Century which testify to a much greater extent of the ice than we see today. Emmanuel Le Roy Ladurie has recently published several of these engravings of Alpine glaciers together with references to written records of their advances and retreats and a whole series of other pertinent written records such as the dates of French wine harvests, the price of wheat, and accounts of houses covered by advancing glaciers and villages evacuated in the early 1600s, in areas now more than a kilometer from the ice. His scholarly treatise, presented with a loving care too often missing from a modern text, argues for an essentially continuous glacial advance in the period 1590-1850.

In both generally cold and generally warm periods, there have been exceptional extreme years. In April of 1815, for example, the volcano Tambora on Sumbawa Island just east of Java erupted with such intensity that there was darkness for three days up to 500 kilometers away. The dust veil in the stratosphere spread round the world and diminished the solar radiation reaching the earth and oceans so that the next summer was very cold and wet: In March, April, and May of 1816 the temperature at Paris was about 1°C. below normal, and July and August were 3°C. below normal. Cooling was also noted after the eruption of Krakatoa in 1883. In 1963, we had an opportunity to examine the disturbance of the stratospheric temperature field accompanying a large volcanic injection of particles into the atmosphere after the eruption of Mt. Agung on Bali. (The eruption produces sulfur-dioxide gas, which becomes an aerosol of sulfate particles.) It was found that temperatures at 20 kilometers increased by about 5°C., due presumably to the absorption of sunlight by the aerosol. The mean residence time for the particulate stratospheric cloud is about two years, after which the aerosol descends into the troposphere, where it is washed out by rain.

The general trend of temperature in middle latitudes since 1900 showed a gradual increase to about 1940 and a gradual decrease in the late 1950s and 1960s which may have been reversed recently. One of the most challenging problems of present day atmosphere-ocean studies is to try to understand the reasons for these trends. Although small, some of the recent changes have practical ramifications which are out of proportion. One of my students, Minoru Tanaka, has recently demonstrated how the atmospheric flow patterns over the U.S.S.R. altered in 1971-72, leading to a very warm and dry anomaly in the wheat-growing area which is directly reflected (after our large grain sale) in the present price of bread and our current wheat stores of less than 100 million bushels.

In a similar vein, the price of soy beans is dependent on the availability of a competitive product—fish meal from Peru. The meal comes from anchovies which are caught off Peru in amounts up to 12 million tons per year. The fish thrive in upwelling cold water which contains their nutrients. This water rises when there are strong offshore winds that carry the surface waters out to the west. The winds, the upwelling, and consequently the water temperatures vary together, and from the graph on the last two pages we see that the years 1965, 1969, and 1972 were years when water temperatures were well above average. The anchovy catch was cut back in these years—in 1972 quite drastically. In the last year the water has cooled again and fishing has recently been permitted once more. (Of course, the water temperature may not always be the prime variable, and there may come a time when the anchovy harvest is nutrient-limited.)

As a final example of the effect of climatic change, we return to the rising motion of the Harley Cell circulation at low latitudes. On a long time scale, we have already seen that coal beds could be traced to this region as the continents moved across the equatorial latitudes. For the past few years the converse has been happening, and the mean latitude of the Hadley Cell circulation has been shifting southward in the African region; each July and August between 1969 and 1972, when the tropical rainbelt normally moves northward and brings rain to the southern fringe of the Sahara, there has been drought in these areas because the belt stayed south of its mean position. As a direct result, many people and large numbers of animals have starved to death. (The belt moved northward toward its mean position in 1974.)

In all three of these cases it is obvious that climatic forecasting would be an extremely valuable tool to possess. Is it feasible? Not at present, certainly, because we lack the background understanding that must precede such forecasting. But in my view, it is not out of the question in future years. After all, the memory of the atmosphere itself may only be a week or so—that

is, only the past week's events are of significance in calculating the atmosphere's present state. However, climatic change depends strongly on the ocean and ice volume, and these systems have an "inertia" which is measured in years if we include the entire system to the ocean bottom. Probing climatic history and the physical factors responsible for change needs a four-pronged approach: a careful monitoring of the important factors in the atmosphere-ocean-land system; synthesis of all our evidence of past climates into global patterns of change; construction of numerical models of the atmosphere-ocean-land system which permit extrapolation back to periods when the earth's orbital characteristics were different than at present and when the solar output itself may have changed; and a study of the theory of climate. Atmospheric temperature, sea-surface temperature, cloudiness, extent of ice, and radiative fluxes can all be monitored by satellite, and remote sounding techniques for aerosol concentration, rainfall, and water-vapor concentration are being developed.

Numerical models, which essentially extrapolate forward in time to produce forecasts of future flow fields, are now in operational use to help with daily weather forecasts. To extend the time scale, computer capacity must be much greater, and there must be a detailed understanding of the oceanic circulation and atmosphere-ocean-ice feedback. Even the Chicago Commodities Exchange would have been interested in reliable oracle bones, had they been available in 1972. But we do not know enough yet to predict whether the next Ice Age is due to start in a hundred, a thousand, or ten thousand years. We are fairly certain though, that it will come before 30,000 A.D., and the energy crisis that is presented as the ice comes grinding down from Canada will surely dwarf that of the 1973-74 winter.

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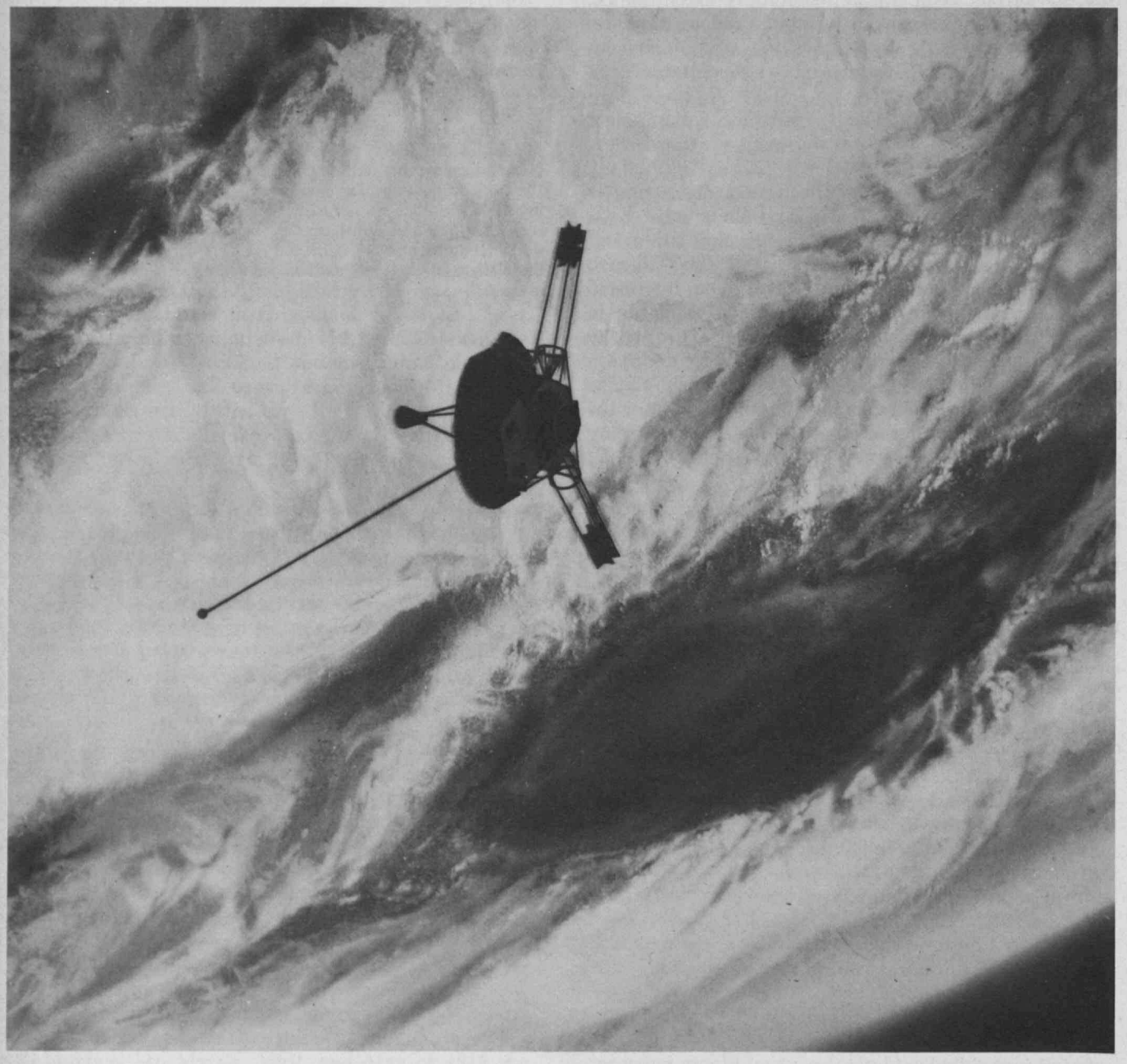
Reginald E. Newell was born and began his education in England. After receiving his B.Sc. in physics from the University of Birmingham, he came to M.I.T., where he received his S.M. and Ph.D., both in meteorology, and subsequently a faculty appointment. He is presently Professor of Meteorology. Dr. Newell has investigated the physics of the upper atmosphere, and the large-scale atmospheric circulation of trace substances, including molecules that are normally there, such as ozone—and others, such as radioactive substances produced by atomic bomb explosions. His present work is on the subjects covered in this article: the climate of the past, and the modelling of the earth's energy budget.

As Pioneer 11 nears its first goal 800 million kilometers away in space, Pioneer 10 is recorded as a "splendid" scientific success and an engineering "triumph"



No one was there—except this N.A.S.A. artist, in his imagination—to see Pioneer 10 glide across the face of Jupiter 130,000 km. above that planet's Great Red Spot on December 4, 1973. Now Pioneer 11, launched on April 6, 1973, is about to repeat this encounter with Jupiter at an even lower altitude. Two results from Pioneer 10: the mysterious red spot is an atmospheric, not a topographic, feature; and the atmosphere surrounding it is structured in belts, without the fine details which on Earth result in storms and rains. Pioneer 10 was a "splendid" scientific and technological success, writes the author, and the two spacecraft are "fresh demonstrations of the potentialities of the human spirit." (Drawing: N.A.S.A.)

William W. Ward
Lincoln Laboratory, M.I.T.

In Celebration of the Pioneers: To Jupiter and Beyond

It is possible to find some benefit in almost every adversity. The legislation of year-round daylight-saving time in 1973 showed some of us the morning stars again. Early risers in 1974 saw Venus, brilliant as a locomotive headlight, soaring in the eastern sky. As 1975 comes on, Venus becomes an evening star again. Its apparent vagaries of motion through the constellations, its waxings and wanings (which must have puzzled the old astronomers), have been well understood since the times of Kepler and Newton. We take for granted the well-nigh infallible prediction of its behavior.

It seems curious that ancient sky watchers, mystified by these apparitions and striving to find understanding in terms of their pantheons, named the planets as they did. Nothing in the sky except the Moon and Sun is consistently brighter than Venus at its best, yet they identified another, dimmer, planet with the Ruler of the Gods. How could they have imagined that Jupiter is so much larger and more massive than all the other planets of our solar system put together? That it is a powerful source of electromagnetic radiation? That it carries in its train a dozen or more courtier satellites?

However our solar system may have originated, the process yielded the Sun, Jupiter, and a collection of smaller fragments. The active exploration of space by the inhabitants of one of those fragments has now been extended to Jupiter itself in the Pioneer 10 and 11 missions of N.A.S.A. These missions are the longest (in time as well as in distance) that humankind has yet attempted. Almost every field of human endeavor is involved (the missions are far more than technology, or science, or both). Their success (already assured for Pioneer 10, whose closest approach to Jupiter came on December 4, 1973) will indeed be a cause for celebration. (All times and dates in this article are given in Greenwich Mean Time.)

Early Exploration of Jupiter

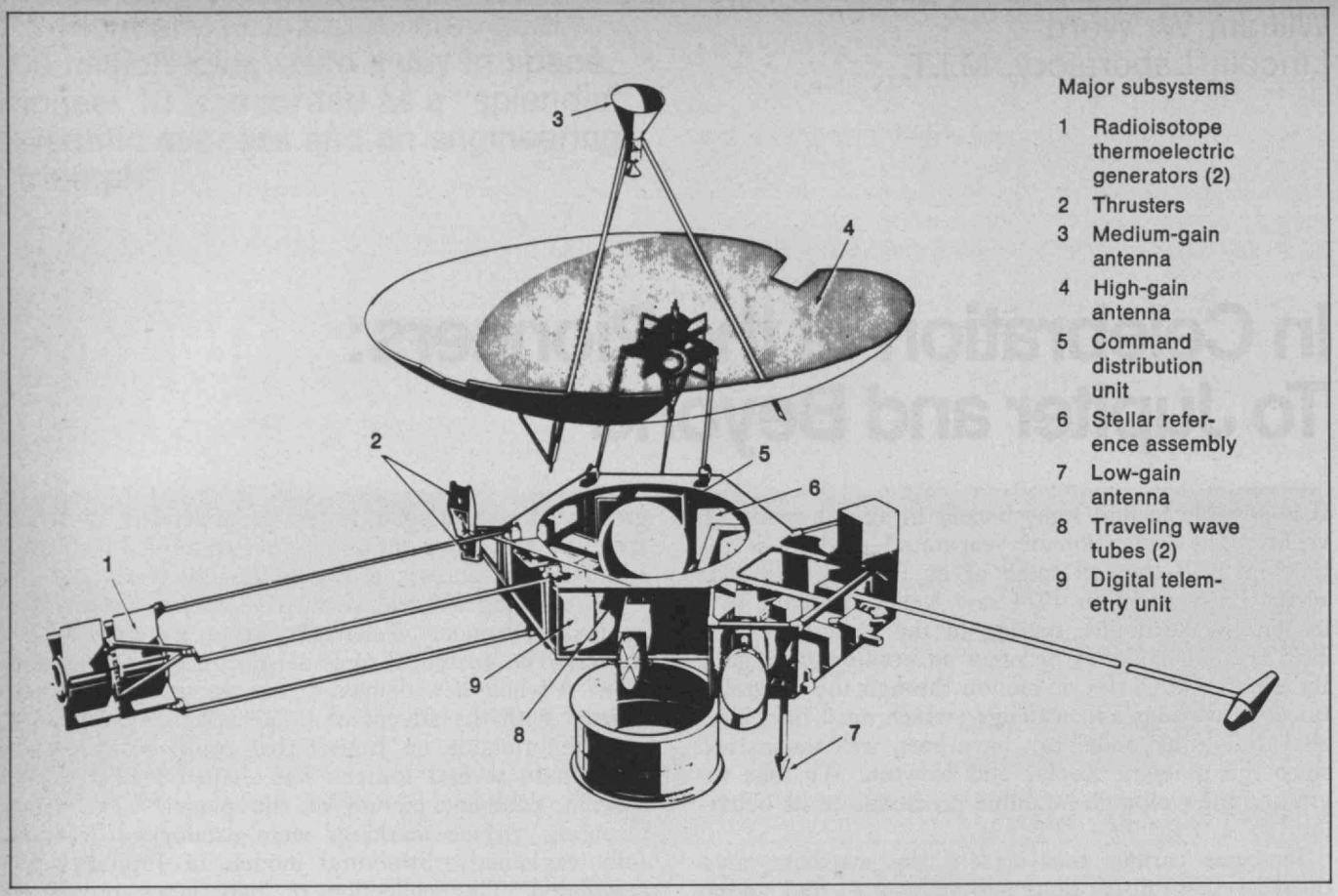
The first exploration of Jupiter took place in Padua, Italy, in 1610. On the night of January 8 in that year, Galileo Galilei put a primitive arrangement of optical hardware to his eye and focussed on the bright object called Jupiter. The instrument wasn't color-corrected; its optical surfaces were only approximately what they should be for best results. Yet this little telescope disclosed a revelation. "Jupiter" consists of a bright disc and several (Galileo ultimately found four) points of light that change in relative position as the night progresses. Here is a solar system in miniature! We can speculate that this sight might have confirmed Galileo's suspicion that Copernicus was on the right track.

The ensuing 350-odd years have brought great advances in astronomy. Telescopic images were much improved. The analytical tools of spectrometry were applied. A whole new domain of remote observation was opened with the advent of radio astronomy. The diverse information on Jupiter that could be garnered from these several sources was shaped into a fairly specific, coherent picture of the planet. The many changing surface markings were catalogued (if not fully explained). Structural models of Jupiter were postulated. This collection of hypotheses projected from limited observations is where our understanding of Jupiter rested until recent progress in astronautics made it feasible to dispatch an ensemble of measuring instruments to the vicinity of the planet itself.

How to Explore a Planet

The steps in the active exploration of a planet are well illustrated by our approach to the Earth's Moon. Not long after the initial achievement of orbital flight (Sputnik 1, 1957) and the first lunar impact (Luna 2, 1959), the U.S.S.R. launched a fly-by mission (Luna 3, 1959) which successfully returned to Earth pictures of the Moon's backside. They are crude pictures by comparison with what was achieved a few years later, but they showed the main features. The U.S.A. had three successful Ranger missions (1964-65) in which photographs of the lunar surface were returned until the spacecraft were destroyed at impact. The first soft landing on the Moon (Luna 9, 1966) was followed by five successful N.A.S.A. Surveyors (1966-68) equipped with an assortment of sensors and manipulators. A series of five N.A.S.A. Lunar Orbiter photographic-survey satellites (1966-67) paved the way for the first of six manned lunar landings by Apollo 11 in 1969. The U.S.S.R. has demonstrated automatic, remote-control techniques (samples of the lunar surface returned by Luna 16, 1970; roving vehicle Lunokhod 1 carried by Luna 17, 1970) that show convincingly what can be done by unmanned exploration.

The major early steps in the exploration of the Moon are being repeated in our exploration of Mars. There have been fly-bys (starting with N.A.S.A.'s Mariner 4, 1965) and a photographic-survey orbiter (Mariner 9, 1971). The U.S. and the U.S.S.R. are each seeking to make a successful soft landing on that planet. But here



The major subsystems of the Pioneer spacecraft shown on this diagram are elements of its six major functional systems: the mechanical structure, communication system, attitude control and propulsion, electrical power, environmental protection, and experiment packages. At least 40 per cent of the spacecraft's weight is concentrated in the structure and radioisotope power generators; only 66 lbs. (the total weight is 565 lbs. at launch) is given over to scientific experiments.

the similarity is likely to end; a manned Mars landing, while probably ultimately feasible from the standpoint of technology, would be a much larger and more demanding enterprise than was Apollo.

Seen in the context of these explorations, the Pioneer 10 and 11 fly-by missions in 1973 and 1974 (Pioneer 11 will make its closest approach to Jupiter on December 3) are the first steps in our active exploration of the outer planets. If there is determination and money, they will be followed by orbiters and soft-landers. The prospects for manned expeditions to the outer planets are unimaginably remote, but it would be rash to say "never."

I. Building the Pioneers

The flight of a successful space probe is basically an exercise in engineering compromise. A host of systems and subsystems must be synthesized and accommodated to one another so that their overall performance achieves the grand goal. The experiment packages—the true payload—are only part of the story. In considering the constituents in detail with respect to the Pioneer spacecraft, we approach them in an order more or less like that in which the spacecraft were themselves constructed.

Structure

The active subsystems of a complex spacecraft must be held together by a passive mechanical structure. At first sight the basic structure of Pioneer 10 and 11 seems a homely creation, but it is in fact a work of engineering optimization of high accomplishment. Its distinctive shape is dictated by the requirement of supporting spacecraft systems and subsystems in relation to one another and to the launch vehicle. The structure is pierced with lightening holes; metal is nibbled away wherever it serves no purpose, for each fraction of a pound of inert weight (mass) carried along displaces some amount of potential experiment payload. It can truly be said of a lean, well-designed structure that "less is more."

Two-Way Communication Links

If we are to learn what a spacecraft is doing and record the scientific data its instruments are gathering, there must be a telemetry link back to Earth. It will generally be useful as well to have a command link from Earth to the spacecraft, so that we can control its behavior and modify the on-board experiments from time to time.

The configuration of Pioneers 10 and 11 is dominated by the dish-like paraboloid communications antenna. It has been made as large (9-ft diameter) as can be accommodated by the aerodynamic fairing which must cover the spacecraft during launch. Much larger antennas are available if we are prepared to accept the risks that go with the choice of an antenna that must be deployed in space.

The communications system—and just about every other electrical feature of the spacecraft—is a virtuosic application of solid-state physics. Most space missions would be impossible without solid-state components, for the size, weight, and power demand of their vacuum-tube equivalents would be intolerable for spacecraft designs. A second criterion is also important: Spacecraft electronics must provide extremely reliable, complex circuits. Commercial, computer-grade component reliability (of integrated solid-state circuits, for example) is not good enough.

Attitude Control and Propulsion

The communications antenna has highly directive performance characteristics for transmission and reception. It is essential to keep the axis of the paraboloid pointing toward Earth, especially as the mission progresses and the separation between the spacecraft and Earth increases. The Pioneer spacecraft are gyroscopically stabilized to revolve around the axis of the communications antenna at about 5 r.p.m. Reorientation and spin control of the spacecraft are achieved by firing six thrusters mounted on the rim of the paraboloid in three pairs of opposing nozzles. These thrusters also serve to change the velocity of the spacecraft, thus affecting its trajectory. They are tiny things, capable of emitting small belches of high-velocity gas to make changes in the angular and linear momenta of the spacecraft. Small increments suffice for such changes because there is no friction against which to contend, and there is lots of time for them to take effect during a long voyage.

How do Pioneer 10 and 11 know how and when to thrust? The two-way communication link is essential, for the spacecraft operate under rather strict Earth control. A conscious design decision was made *not* to equip the spacecraft with complex on-board systems for near-autonomous control but rather to turn the equivalent capacity into payload for scientific experiments. There is only limited capability for on-board storage of a prearranged sequence of commands.

The spacecraft determine their attitudes in inertial space by means of optical sensors which seek out the Sun and the star Canopus. The latter luminary, not visible in the northern sky, is the second-brightest star (exclusive of the Sun) visible from Earth, Sirius being the first. Even though it is dimmer, Canopus is preferable to Sirius as a navigation beacon for two reasons:
—Sirius has several relatively bright stars as neighbors and lies near the edge of the Milky Way, whereas Canopus is fairly isolated; a star sensor is more likely to mistake another star for Sirius than for Canopus.
—For travel in or near the plane of our solar system, the angle between the Sun and Canopus is generally larger than that between the Sun and Sirius, thus giving a better fix.

The communications receiving system itself also serves as an attitude sensor on Pioneers 10 and 11. If a signal from Earth is to be detected, the antenna must already be pointed in approximately the correct direction. But the pointing accuracy is refined automatically: the antenna feed is moved through a series of small offsets in search of the strongest signal.

Pioneers 10 and 11 will eventually run out of gas (literally) and will find themselves unable to keep their antenna beams pointing toward Earth. That is one of the ways (barring a chance catastrophic encounter with a hunk of cosmic debris) that the missions can come to an end, many years after the Jupiter encounters.

Electrical Power

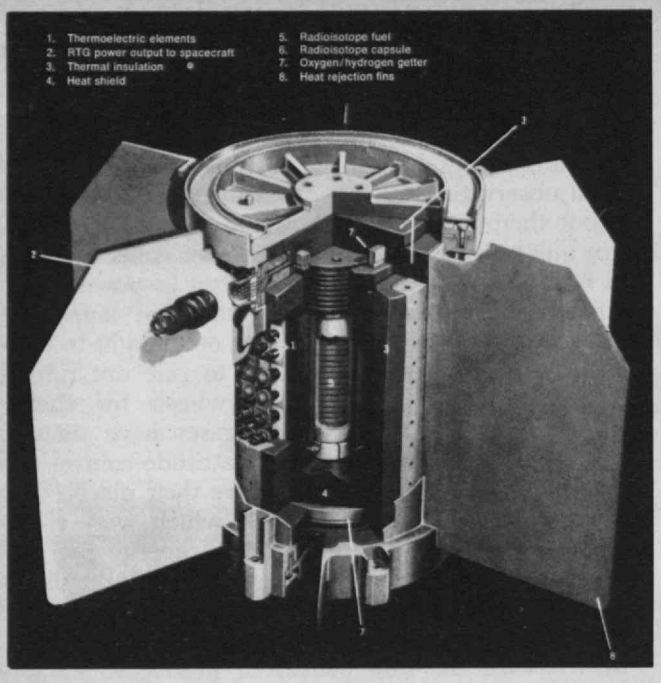
Interesting things have been learned from radar and optical observations of passive spacecraft in Earth orbit, but there is no point to sending a probe far into space unless it carries active systems for collecting data and returning it to Earth. The energy to power these systems must either have been stored at launch or be obtained by conversion (such as of sunlight to electricity) along the way. It is easy to rule out rubber bands, clockwork motors, and flywheels for energy storage. Compressed or liquified gases have limited, specialized usefulness (such as for attitude control and propulsion, as above). Batteries have their place (they powered the first Earth satellites, which were short-lived), but they do not store enough energy per unit mass for a multi-year voyage such as to the outer planets. Hydrogen-oxygen fuel cells have been used for manned missions of intermediate duration (Gemini, Apollo), with the side benefit of producing potable water for the crew.

Most long-lived spacecraft are powered by solar-cell arrays, sometimes augmented by rechargeable batteries to maintain operation during eclipse. But a mission to the outer planets moves the spacecraft far from the Sun, so present-day solar-power converters are inadequate. When Pioneers 10 and 11 are in the vicinity of Jupiter, they are about five times as far from the Sun as when they were near Earth, and the solar irradiance decreases to only 4 per cent of what it was near Earth.

Energy to operate the on-board systems of Pioneers 10 and 11 comes from plutonium-238 in four radioisotope thermoelectric generators (RTGs) carried by each spacecraft, developed for the Pioneers by the Atomic Energy Commission. The nuclear disintegrations that take place in the core of each RTG yield heat that is transformed to electricity by a surrounding array of thermoelectric couples. The RTGs are mounted in pairs on booms extending about 10 ft. from the axis of the spacecraft, to minimize the effects of RTG-produced particulate radiation and magnetic fields on the experiment packages.

The total electrical power required by the subsystems of Pioneer 10 is remarkably small—a steady load of about 110 W, the equivalent of an ordinary household light bulb. A third of this power disappears into electrical-utility overhead (heat losses in wiring and conversion equipment). A quarter of the power is devoted to the science experiment packages. Another quarter is taken by the telemetry transmitter. The 8-W. signal of the transmitter (a very dim light bulb indeed), handled through the 9-ft.-diameter paraboloid and a tremendous, sophisticated Earth terminal, sufficed for communication to Earth with relatively few errors at an information transmission rate of 1,024 bits/sec. (less than half the rate of a minimum-width telephone channel for voice communication) when the spacecraft passed by Jupiter about 800 million km. from Earth.

Pioneer 10 is now outward bound from our solar system (the first manmade object to leave it). Communication can be maintained despite the increasing



Four radioisotope thermoelectric generators (RTGs) power each Pioneer spacecraft. Heat from the radioactive element in the center is transformed into electricity by thermoelectric elements surrounding it. Most spacecraft utilize solar energy; but the Pioneers' destination is too far from the Sun. Precautions to protect the spacecraft from RTG radiation—and to protect humans who might be affected should a Pioneer mission have been aborted—consumed precious pounds of the Pioneer payload. (Diagram: N.A.S.A.)

separation by reducing the data transmission rate; when the separation is four times the distance to Jupiter we might hope for a data rate of 64 bits/sec. (1/16th of that at encounter, because the signal fades with the square of the distance). Other technical factors will limit the 64-bits/sec. range to about 2.5 billion km., to be reached by Pioneer 10 in 1978. Assuming that the other essential spacecraft systems hold up, the increasing separation between Pioneer 10 and the Earth terminal beyond that range will be accompanied by deterioration—an increasing proportion of errors—in the received data, to the point that it becomes meaningless. It would in principle be possible to recover the link by improving the Earth terminal, but that facility (of which more later) is already pushing the limits of available technology. However, the brute-force solution of building another large antenna system alongside the first one and combining their received signals would increase the working range substantially.

The power available from the RTGs early in the mission is more than needed to operate the spacecraft. The excess power is dissipated in resistive loads. The power-decay rate for the four RTGs corresponds to the gradual exhaustion of the $^{238}PuO_2$ fuel (which has a half-life of 87.6 years) and the corresponding reduced supply of heat to the thermoelectric couples. This is another way in which Pioneers 10 and 11 will eventually cease to function, for they cannot tell us anything more when they can no longer power their telemetry transmitters.

Environmental Precautions

Somewhat less than 8 W. is radiated by the antenna as a useful signal for communication with Earth. The remaining 100 W. of electrical power in the spacecraft must be radiated as heat. In the case of Pioneer 10, each of the four heat sources was producing about 600 W. at encounter, of which only about 36 W. was being transformed to electrical power.

The surface of each RTG was specially treated to enhance its emissivity and thus help dump the waste heat. Special thermal treatments are also needed for the rest of the spacecraft. The antenna always faces the Sun and so has the opportunity to overheat. The back of the spacecraft (where most of the equipment boxes are mounted) never faces the Sun—only cold, black space. Provision must be made so that the electronic boxes are neither too hot nor too cold; the former extreme is always fatal and the latter can be. For these reasons the thermal design of the spacecraft is of just as much importance as its mechanical design.

To develop systems for temperature control in these critical areas, the Pioneer spacecraft were checked extensively before launch in laboratory test facilities. A large vacuum tank lined with black-painted walls containing liquid nitrogen is a reasonable approximation to the environment of space, and the Sun can be simulated by aiming the output of a suitable floodlight (such as a xenon arc lamp) onto the spacecraft in such a thermal-vacuum chamber. A mission such as that of Pioneers 10 and 11 includes many different thermal regimes, ranging from the full glare of the Sun shortly after launch to eclipse by Jupiter itself as the spacecraft passes behind it, and each of these was simulated in this way during the design of the spacecraft and the heat controls established accordingly.

Mechanical testing (intended to simulate the rigors of launch) is generally done separately. Fashions in mechanical-qualification testing have changed over the years. Most such testing of individual subsystems is done using electromagnetic shakers to which test articles are attached; the shakers apply excitations representative of the shocks and vibrations measured on previous rocket flights. The mechanical testing of complete spacecraft is sometimes done in a large closed chamber driven by acoustic horns fed streams of high-velocity gas. The enveloping sound field simulates the launch environment in which there is atmospheric coupling from the rocket motors through the aerodynamic fairing to the payload.

All this mechanical testing is a great nuisance. If only someone would invent a gentle rocket that could put payloads into orbit with low accelerations! But there is no prospect of such an invention; indeed, it can be argued that the necessity to build for survival of the rigorous launch environment is a blessing in disguise. There is no question that the people who make the hardware do things with more care because they know they will face moments of truth during pre-launch testing, and because they know they can't fix something if it fails after launch.

Seen in these terms, the heralded possibilities for payload repair in orbit and retrieval from orbit offered by N.A.S.A.'s Space Shuttle Transportation System, now under development, are mixed blessings. We shall have to learn to build spacecraft very differently, for they are now poorly adapted to repair except in a

ground-based laboratory with extensive support facilities. Will the possibility of in-orbit repairs erode the compulsive dedication to craftwork perfection that has been characteristic of successful, long-lived spacecraft?

It was anticipated long before Pioneers 10 and 11 were launched that they would encounter strong regions of trapped particulate radiation in the vicinity of Jupiter. Some precautions to protect the spacecraft against such radiation, and against the radiation sources (the RTGs) which are part of its equipment, were taken in the design of the spacecraft (such as mounting the RTGs on booms extending away from the electronic boxes). But total shielding was not practical, particularly because no one could say how much would be enough. One object of these Pioneer missions was to make the first *in situ* measurements of Jupiter's radiation field. Here, then, was taken a calculated risk. The principal information gained might be only that Jupiter's radiation was so strong that the spacecraft could not survive (that is, continue to operate) after entering it.

Launch Vehicle

Pioneers 10 and 11 were each launched by a three-stage rocket. That great propulsive power was needed to send the spacecraft away from Earth at a post-boost relative velocity of about 14 km./sec. For comparison, the lowest important velocity for space travel is about 7.5 km./sec.—the speed of a satellite in low, circular, Earth orbit. The second important speed, Earth escape velocity, is about 11 km./sec. Pioneers 10 and 11 raced past the orbit of the Moon about 11 hr. after launch; Apollo missions took 65 to 70 hr. to cover the same distance.

The first stage was the Atlas missile, an old sword that has been beaten into a plowshare. Originally developed by the U.S.A.F. in the 1950s for the first American I.C.B.M. force, Atlas continues to be manufactured long after its original military role has been taken over by newer vehicles. Today Atlas is used for a variety of missions, from launching space probes such as Pioneers 10 and 11, to putting commercial communication satellites into Earth orbit. It burns liquid oxygen and RP-1 (a kerosene-like fuel).

The Centaur second stage was developed by N.A.S.A. for a broad spectrum of missions; it burns liquid oxygen and liquid hydrogen. The third stage (a solid-fueled rocket) is an uprated version of the retromotor used for the Surveyor lunar soft-landing vehicle.

This casual description hides the fact that putting a multistage vehicle and its payload together is not quite as simple as picking parts from an Erector Set. There are interfaces to be defined and interactions to be considered.

Science Experiment Packages

Only after everything else has been put together to make a spacecraft do we finally come to discussing the things that furnish the fundamental justification for the mission. This sequence may seem illogical, but it is in fact not unreasonable; for the things we have already discussed are for the most part within the province of the spacecraft integration contractor (in the case of Pioneer, TRW Systems Group), whereas the numerous experiment packages come through N.A.S.A. from several different investigators and their organizations.

Electrical Power for Pioneer 10:	Power (W.)
Scientific experiments	24
Communications and data	8.9
Radio transmitter (telemetry)	27.8
Radio receiver (command)	5.9
Attitude control, propulsion	5.9
Cabling and conversion losses	36.1
Total steady load	108.6
Transient loads	5 to 12
Power available from 4 RTGs at encounter	~145

Weight of Pioneer 10 at Launch:	Weight (lb.)
Structure and thermal control and balance systems	126
Attitude-control system, propulsion (dry)	37
Propellant, pressurant	61
RTGs (nuclear power)	120
Power system	39
Communications and data system	34
Antennas	46
Cabling and power distribution system	36
Scientific experiments	66
Total spacecraft weight	565

Top: The Pioneer spacecraft are powered by radioisotope thermoelectric generators—four per spacecraft—which generated about 36 W. each at encounter; their power-decay rate is about 0.2 W./month each. Two remarkable facts emerge from this table: the entire spacecraft operates on no more energy than is required for many household electric lights; and the transmission of information to Earth at the rate of over 1,000 bits/sec. from the vicinity of Jupiter required less than 30 W.

Bottom: At launch, Pioneer 10 weighed 565 lbs; only 66 lbs of this represented the scientific experiments. In contrast, the three-stage Atlas/Centaur/Surveyor rocket system used to push Pioneer 10 on its path for Jupiter weighed 323,000 lbs.

Seen in comparison with the booster stack and even with other spacecraft systems (see bottom table on this page), the payload is only a small appendage. We are not overwhelmed by 160 tons of skyrocket, for successful big launches are no longer a novelty. But it is a little distressing to see how small a fraction of the spacecraft weight—about 12 per cent—can be devoted to the science experiment packages. We expect the RTGs to be heavy, for their radioactive cores come from the high end of the Periodic Table. But we must put even more mass into the structure, the thermal-control ar-

rangements, and plebeian necessities such as masses that must be added at final assembly to assure the static and dynamic balance of the spinning, stabilized spacecraft.

We are reminded of an expedition to climb a remote, difficult mountain peak. In the case of Everest, two men (Hilary and Tensing, 1953) completed the initial successful ascent. They were the counterpart of the science experiment packages in the Pioneer 10 and 11 missions. The hundreds of porters, the tons of supplies, the progressively more austere base camps at higher altitudes; the cadre of capable climbers from among whom the final choice was made—all can be put into parallels with the features of a space-probe mission. We will return to this analogy later.

The times of the launches of Pioneers 10 and 11 were set by the relative motions of the two planets concerned and the speeds of the spacecraft. The two planets are in approximately circular, coplanar orbits, one (Earth) circling the sun in one year, the other (Jupiter) doing so in 11.86 years. Between an outer planet with a period T_o (11.86) and an inner planet with a period T_i (1), a given angular relationship recurs at intervals $\Delta T = T_oT_i/(T_o - T_i) = 11.86/10.86 = \sim 1.1$, or 13 months. Pioneer 10 was launched on March 3, 1972, when Earth and Jupiter were in relative positions to make its trajectory most favorable, and Pioneer 11 was launched on April 6, 1973. The central instants of the two Jupiter fly-bys are on December 4, 1973, and—according to plan—on December 3, 1974. Pioneer 11's somewhat different trajectory will have gained it a month of travel time over Pioneer 10.

Communications Facilities on Earth

Three great Earth terminals located about 120° apart in longitude are part of the two-way communication system linking Pioneer 10 and 11 with controllers and scientists. The first terminal was for good technical reasons built in a desolate region of California, and its companions in Spain and Australia (spaced so as to provide continuous coverage despite rotation of the Earth) are equally inconspicuous; so the terminals are little known to the public—a pity, for these terminals are magnificent engineering achievements which should be tourist attractions. They are more significant as benchmarks for what humankind has accomplished and may yet aspire to than are most monumented battlefields.

To describe these antennas as 210-ft.-diameter paraboloid "dishes" is correct but inadequate. Briefly, the antenna surface (which is about an acre in extent, substantially larger than a football field) is held to within a fraction of an inch of the desired shape, and the axis of the paraboloid is pointed in the desired direction to within a few hundredths of a degree. These mechanical dimensions are maintained across a wide range of elevation angles, by day (in the heat of the sun) and by night, in summer and winter. The transmitter operates in a narrow frequency band near 2110 MHz., at an average power level of about 400 kW. The receiving system (built around a maser) uses a narrow band of frequencies near 2292 MHz. and approaches in sensitivity the limits predicted from our understanding of quantum electronics. The deviation of these transmitted and received frequencies from the ratio of 240 to 221 (which is rigidly established in the spacecraft communications equipment) is a sensitive measure (through Doppler shift) of the spacecraft's motion relative to the earth.

The terminals employ digital computers extensively for signal processing, and there are elaborate recording facilities as well as communication links between each terminal and the central control facilities for Pioneer missions at Ames Research Center in Mountain View, Calif.

Environmental Impact

No enterprise of this magnitude is consummated without submission and acceptance of an environmental impact statement.

On nominal missions, Pioneers 10 and 11 leave the Earth never to return. The environmental impact associated with such missions (dispersal of rocket exhaust plumes in the atmosphere, down-range impact—at sea—of the spent Atlas booster, etc.) is understood and accepted. The main item of concern is the $^{238}PuO_2$ in the four RTGs—a total of about 80,000 curies.

There is no possibility of a nuclear-criticality incident, for the total quantity of fuel is less than a critical mass even if it were to be arranged in the most reactive geometry. What did matter was the possibility of an abortive mission in which the highly toxic, non-biodegradable fuel might be dispersed by blast, fire, impact, or reentry. Thus a substantial amount of the weight of each RTG fuel capsule was devoted to thermal and mechanical protection of the fuel itself. On the basis of tests, analyses, and simulation, it was concluded that Pioneers 10 and 11 were an acceptable risk from the standpoint of nuclear safety, and the launches were approved.

So the preparations were at last complete; the formalities had been complied with, and the several informal traditions prefatory to a successful rocket launch had been observed. Pioneer 10 was launched from Cape Kennedy on the fourth attempt, five days into the 16-day launch window. Pioneer 11 was launched on the first attempt.

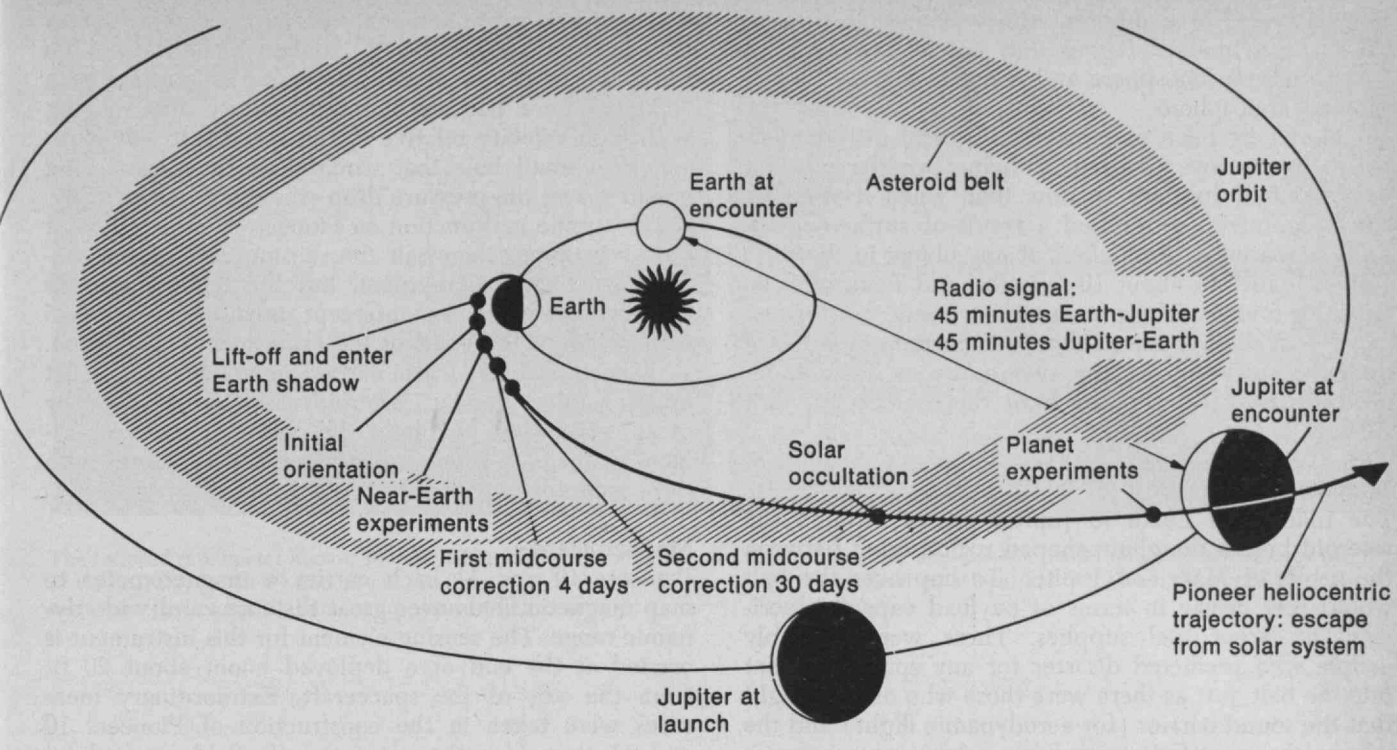
II. Science Aboard the Pioneers

Some of the experiments associated with Pioneer 10 and 11 return useful data throughout the mission, from soon after launch until communication with the spacecraft ultimately ceases. Others were designed to function only during the comparatively brief planetary encounter. Pioneer 10 was a splendid success: All experimenters obtained good data. The quick-look results of the encounter experiments were published collectively a few weeks after the event in *Science* for January 25, 1974. Further results have since been published for individual mission experiments, and a new unified picture of Jupiter emerged with the appearance of the September 1, 1974, issue of *Journal of Geophysical Research*. However, many implications of the results may not yet have become apparent. The process of scientific rumination will go on for a long time.

We can give in this article only brief, superficial reviews of a few experiments and of their results. A full account would be vastly richer.

Celestial Mechanics

The spacecraft moves in a fundamentally simple way under the gravitational influences of the Sun, the



This diagram summarizes the history of Pioneer 10's successful flight to Jupiter, the first step in man's active exploration of the outer planets. Why did we do it? asks the author. "In recognition," he replies, "of the fact that science continues to be a worthy human endeavor. . . . Pioneers 10 and 11 . . . are fresh demonstrations of the potentialities of the human spirit."

planets, and their moons, as well as in response to the pressure of solar radiation. All of these factors are known to some degree of accuracy. Mission trajectory planning was based on predictions made by using the known numbers.

In flight, the two-way communication link is the primary means for tracking the spacecraft. In addition to the angle measurement implicit in successfully pointing a very narrow Earth-terminal antenna beam at the spacecraft, there is the capability to measure the range rate (as mentioned above) once a minute to within a fraction of a mm./sec. This velocity can be integrated numerically over long intervals of time, producing an accurately measured trajectory corresponding to the motion of the spacecraft.

Now that the actual trajectory has thus been measured, the problem can be turned around (with the aid of large-scale computation), and improved estimates of planetary masses and orbits and solar-radiation-pressure effects can be obtained.

When Pioneer 10 and 11 fly by Jupiter, the effects of the Sun and other planets are comparatively small and relatively constant. Study of the trajectory of Pioneer 10 during the encounter phase has given greatly improved estimates of the masses of Jupiter's four larger moons (those discovered by Galileo) and of the gravitational field of Jupiter itself. That field was expected not to be perfectly spherically symmetrical, if for no other reason than the polar flattening of the planet caused by its rapid rotation rate (one Jupiter day is about ten Earth hours). Similar studies of satellite motion around the Earth's Moon during the Lunar Orbiter missions disclosed the presence of several large anomalies in the Moon's gravitational field, apparently due to concentrated masses (mascons) beneath the lunar surface. It appears from the Pioneer 10 data that there are no such mascons in Jupiter. It is almost certainly a liquid planet having at most a small, rocky core. In particular, the failure of Jupiter's Great Red Spot to affect the trajectory of Pioneer 10 during the fly-by furnished another bit of evidence that the Spot is an atmospheric rather than a topographic feature.

Radio Occultation

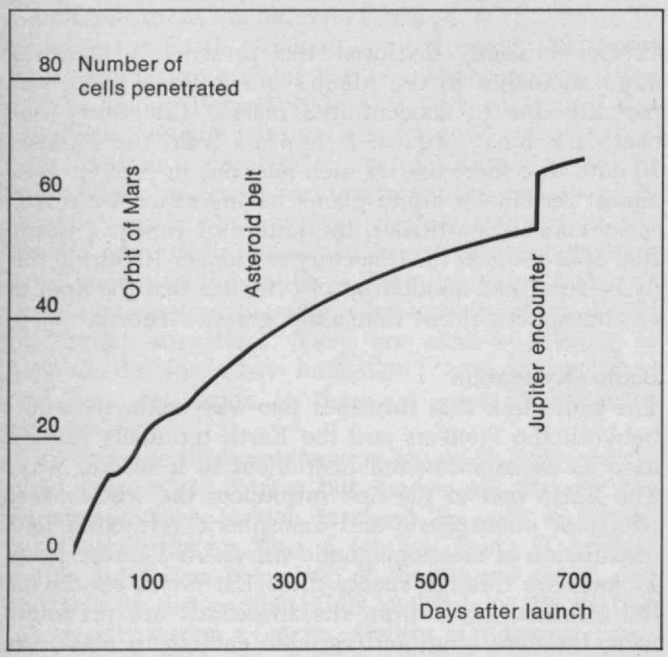
The radio link that furnishes two-way communication between the Pioneers and the Earth terminals can be used as an experimental instrument in a second way. The Earth end of the link introduces the well-known effects of atmospheric and ionospheric refraction and attenuation of electromagnetic waves. As Pioneer 10 or 11 journeys through space, these Earth-end effects on the communication from the spacecraft are predominant; they are large and variable enough to mask the small, slowly changing propagation effects that might be caused by the interplanetary medium. But when the spacecraft passes behind Jupiter, there are two brief intervals (upon entering and emerging from occultation) when the radio link extends through any atmosphere that Jupiter possesses. Occultation experiments are not new in optical astronomy—stars have been commonly used as the signal sources; but Pioneer 10 and 11 provide coherent, known signal sources that do not twinkle appreciably when seen through Earth's atmosphere.

The remarkably precise trajectory of Pioneer 10 took it not only behind Jupiter (as seen from Earth) but also—and at a different time—behind Io, one of the Galilean moons. It was thus possible to establish that Io has an ionosphere and hence a neutral, though rarefied, atmosphere.

Io has long been of interest to optical astronomers. It has the curious property of being brighter when it comes out of Jupiter's shadow than when it went in. The brightness (considered a result of surface reflectivity, apparently the highest of any object in the solar system) fades in about 10 minutes, and Io turns from white to orange. The measurements made by Pioneer 10 support the hypothesis that Io is covered by a fall of methane snow during the two hours of each 42-hr. orbit when it is protected from the Sun by Jupiter's shadow.

Meteoroid Detector

The road from Earth to Jupiter passes through the asteroid belt, a doughnut-shaped region lying between the orbits of Mars and Jupiter. To hop over the belt would cost dearly in terms of payload capacity sacrificed to larger fuel supplies. There were probably people who predicted disaster for any spacecraft sent into the belt, just as there were those who once thought that the sound barrier (for aerodynamic flight) and the thermal barrier (for atmospheric entry) were impenetrable. Pioneers 10 and 11 both survived their passage through the belt, and the data returned by their on-board instruments showed it to have been not especially perilous. It often pays to do an experiment.



Pioneer 10's meteoroid detector was put into operation about 80 days before the spacecraft was due to cross the orbit of Mars, and on the average one particle of interplanetary matter was then recorded every three days. There were no detections for about three weeks as Pioneer 10 traversed a region somewhat inside the orbit of Mars; its influences (and perhaps those of Earth) sweep out a corridor in space. Then came the asteroid belt—considered a possible zone of disaster for the spacecraft; but it yielded only one particle every 25 days on the average. Near Jupiter the rate increased precipitously, with 10 particles encountered during the 64 hours of the Pioneer 10 fly-by. Beyond Jupiter the interplanetary environment resumed.

A survey of small particles (masses as small as 10^{-9} g., diameters down to 10 μm.) was carried out by means of pressurized stainless-steel "balloons" affixed to the back side of the paraboloid antenna. Penetration of a "balloon" by a particle of interplanetary dust moving with high velocity relative to the spacecraft would result in a small hole that would leak the pressurizing gas to space; the pressure drop was sensed electrically. An electronic malfunction on Pioneer 10 caused loss of data from more than half the sensing cells of the meteoroid-detection equipment, but the remaining units (corresponding to an intercept area of about 0.25 m.^{2}) achieved the goals of the experiment (see chart).

Pioneers 10 and 11 also carried instruments to detect and measure passing asteroids and meteoroids by means of scattered sunlight. The results of this experiment, while of a different character, are consistent with those from the impact detectors.

Magnetometers

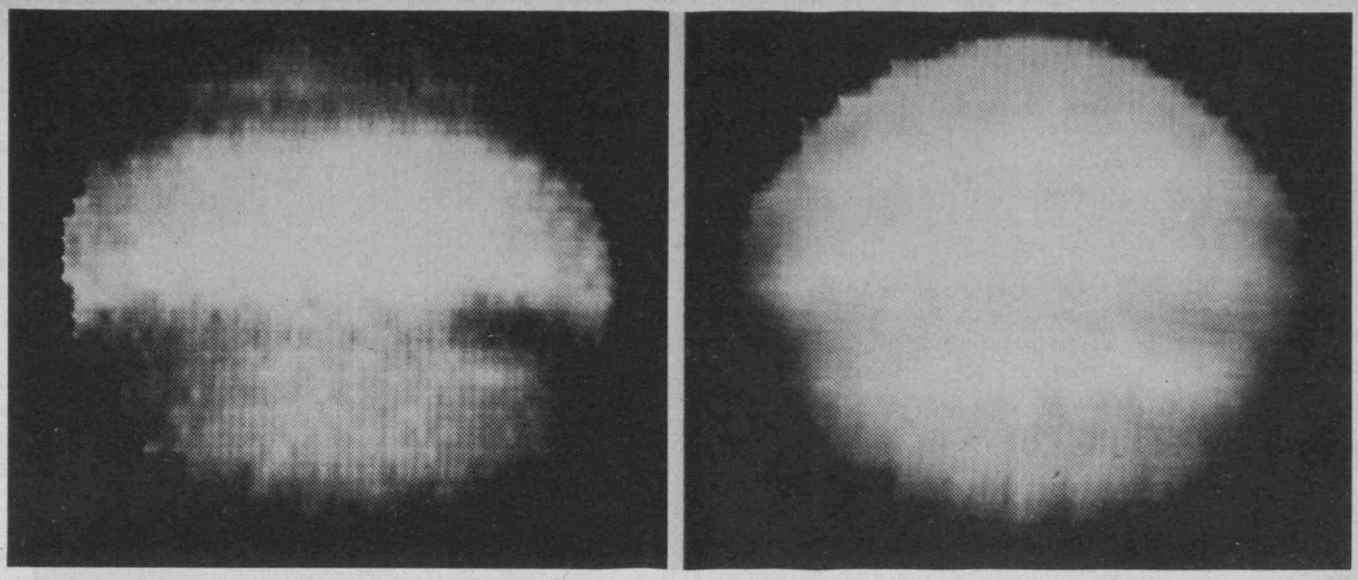
Pioneers 10 and 11 each carries a magnetometer to map magnetic fields over great distances and wide dynamic range. The sensing element for this instrument is carried at the end of a deployed boom about 20 ft. from the axis of the spacecraft. Extraordinary measures were taken in the construction of Pioneers 10 and 11 to reduce the net magnetic fields caused by spacecraft subsystems and electronics so that the sensitivity inherent in the instrument could be achieved in practice.

After Pioneer 10 left the Earth far behind, not much of magnetic interest happened until about a week before Jupiter encounter, when the spacecraft crossed the "bow shock wave," a boundary (named by analogy to a phenomenon in aerodynamic flow) at which the velocities of electrons and ions streaming out from the Sun (called the solar wind) change abruptly as they encounter the magnetic field of Jupiter. There was another sharp perturbation a day later when Pioneer 10 crossed the magnetopause and entered Jupiter's magnetosphere—the region occupied by the planet's magnetic field into which the solar wind does not penetrate.

As the spacecraft approached Jupiter during the next few days, a well-defined 10-hour periodicity was observed in the growth of the magnetic field. Radio astronomers, noting a similar periodicity in radio signals received from Jupiter, had hypothesized that the axis of the planet's magnetic field was different from its axis of rotation. Pioneer 10's observations confirm this hypothesis, as well as supplying new measurements of the tilt angle—about 11°.

Pioneer 10 also confirmed the radio astronomers' inference that the orientation of Jupiter's magnetic dipole (the position of its North and South magnetic poles) with respect to its orbit plane is opposite to that of the Earth's magnetic dipole. No planet other than these two is known to have a substantial magnetic field.

Pioneer 10 came within 130,000 km. of Jupiter's cloud tops at closest approach, measuring a magnetic field there about half that at the surface of the Earth. Pioneer 11 will swing to within 42,000 km. of the cloud tops and so will encounter a stronger magnetic field. It has accordingly been equipped with a second magnetometer of a different type to allow measurements beyond the range of the first instrument.



The infrared radiometer aboard Pioneer 10 yielded scans such as these at 20 μm. (left) and 40 μm., confirming that the cloud surface of Jupiter has the same temperature whether in sunlight or shadow, and that the planet radiates more energy as heat than it receives as heat and light from the Sun. (Photos: N.A.S.A.)

Plasma Analyzer

Pioneers 10 and 11 each carries a plasma analyzer that can measure the direction of travel, energy-level spectrum, and density of the electrons, protons, and alpha particles in the flowing plasma of the solar wind. These instruments return data throughout the flight, and their usefulness is enhanced by the availability of data from similar instruments carried by Pioneers 6 through 9, which continue to perform well after years in solar orbit.

The observations of the Jupiter encounter made by the Pioneer 10 plasma analyzer were complementary to those made by the magnetometer. There were dramatic changes in the plasma flow when the bow shock was passed, and no plasma flow was found inside the magnetopause. But these two boundaries are by no means rigid. They were seen to pulsate in and out from time to time, so that Pioneer 10 experienced repeated transitions. The electrodynamics of Jupiter and its surroundings are far from simple.

No one knows just how far out the solar wind blows. Where it stops blowing is one definition of the boundary of the heliosphere—the Sun's atmosphere, in a sense. Perhaps Pioneer 10 will answer that question on its journey away from our solar system.

Infrared Radiometer and Imaging Photopolarimeter

Everybody likes a picture. Pioneers 10 and 11 were well-equipped to satisfy that human craving.

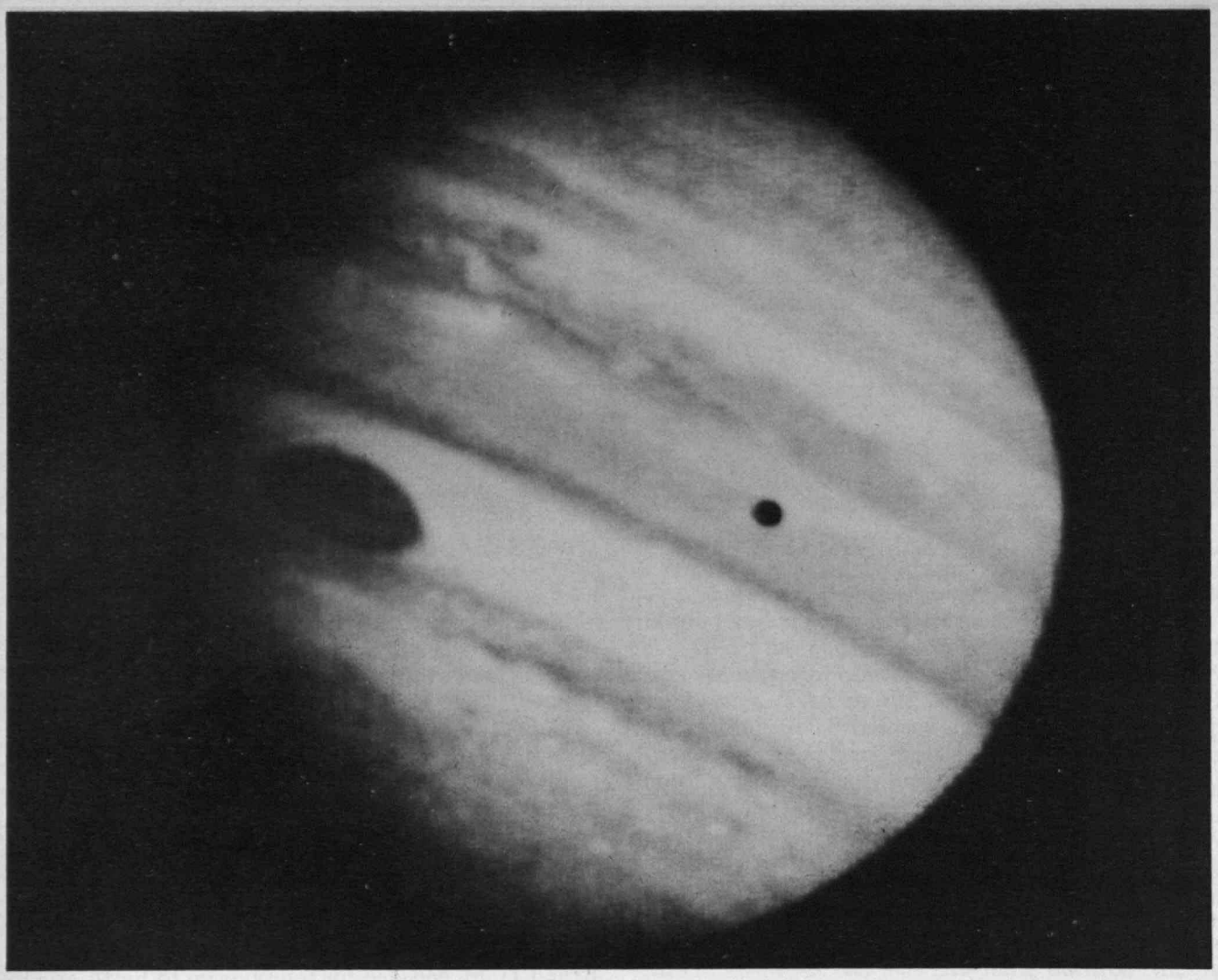
The Pioneer 10 infrared radiometer (IRR) yielded data from which have been constructed isothermal (temperature contour) maps of Jupiter's upper atmosphere at wavelengths of 20 and 40 μm. They disclose (among many other things) that, as expected, Jupiter has the same brightness temperature in shadowed and in sunlit regions (its shadowed regions cannot be seen from Earth). They confirm the conclusion that Jupiter radiates far more power (as heat) than it receives in the light and heat from the Sun.

The pictures from the IRR are of more scientific than esthetic appeal. The truly dramatic pictures came from Pioneer 10's imaging photopolarimeter (IPP). As its name implies, the IPP analyzes light received by its telescope into two polarizations. Polarization analysis of sunlight scattered from Jupiter's atmosphere, for example, can disclose some physical properties of the scatterers. Red and blue components extracted from the two polarizations by band-pass filters on Pioneers 10 and 11 are encoded for transmission to Earth, where what the IPP sees is traced out in a two-dimensional scan, as in a TV raster.

Candor compels the admission that some of the most striking IPP pictures of Jupiter (such as the one showing the Great Red Spot and the shadow of Io on the planet's surface, reproduced on the opposite page) are in part synthetic. Picture-tube phosphors for color TV provide three additive primary colors, but the IPP readout provides only red and blue. The green signal was manufactured on Earth using a recipe based on the measured red and blue signals and the results of previous terrestrial observations of Jupiter.

In the control of the IPP, just as for the attitude-control system, reliance was placed on the availability of reliable telemetry and command links with Earth at critical junctures. Some 15,000 separate commands were generated before the launch for use as might be needed to control the IPP during the two months of pre- and post-encounter observations. At the time of Jupiter encounter, the round-trip travel time of light (and also of radio signals carrying telemetry and commands) was 92 min., so any abnormality occurring on board Pioneer 10 could not be corrected by command until at least 92 min. after its occurrence. Some abnormalities (perhaps caused by Jupiter's fierce radiation belts) did occur, but only a few sets of imagery and polarization measurements were lost.

Pioneer 10's IPP observations included views of the terminator, the moving line that divides the sunlit and



Perhaps the most dramatic picture of Jupiter from Pioneer 10 is this one, showing the Red Spot, the shadow of Io, and the surface cloud structure from an altitude of 2.5 million km. Pictures such as this were made by Pioneer 10's imaging photopolarimeter, which scans a narrow viewing window as the spacecraft spins. As much as 100 min. are needed to complete all the high-resolution elements combined in a picture; computer-based programs were used on Earth to resolve geometric distortions and flaws from the data-transmission channels and to extrapolate a third color from the red and blue images available. (Photo: N.A.S.A.)

the shadowed sides—day and night—of any planet. The Earth's terminator, as seen from space, is by no means a simple geometric locus. Differences in terrain elevations and in cloud heights make the Earth's terminator rather ragged. Convection in the Sun-warmed atmosphere combines with the effects of Coriolis forces (corresponding to the Earth's rotation) to produce the enormous cloud spirals known as cyclones and anticyclones which are readily seen from Earth-orbiting sensors. In the same way, views of Jupiter's terminator give insight about the structure of its atmosphere. But Jupiter's atmosphere shows very few cyclonic structures, though the same basic forces are presumed to be at work there. It appears that Jupiter's rapid spin rate and large size (resulting in 10 km./sec. speed for equatorial cloud tops, as compared with about 0.5 km./sec. on the Earth's equator) stretch its persisting weather patterns into belts.

Long before Pioneer 10 approached Jupiter, the IPP was put to analyzing the gegenschein, a sky glow seen from Earth as a faint brightening in the direction away from the Sun. There has been debate about whether the gegenschein represents sunlight scattering from generally distributed interplanetary dust or from possible Earth-associated gas or dust tails. The Pioneer 10 IPP settled the matter conclusively: It saw the gegenschein when the spacecraft was far away from Earth, with a markedly different antisolar direction. The partisans of interplanetary dust prevailed.

In addition to IRRs and IPPs, Pioneers 10 and 11 carried ultraviolet photometers for coverage in that part of the spectrum. These instruments measured hydrogen and helium abundances in the atmosphere of Jupiter—82 and 17 per cent, respectively.

Radiation Belts

Pioneers 10 and 11 each carries a set of instruments to measure particulate radiation falling on the spacecraft—cosmic-ray and Geiger-tube telescopes and charged-particle and trapped-radiation detectors. These provide complementary capabilities useful in interplanetary space as well as in the vicinity of Jupiter. The Pioneer 10 instruments disclosed a ferocious environment, far stronger than has ever been measured

elsewhere in space. The form and distribution of Jupiter's inner and outer radiation belts bear close relation to the inner and outer magnetic fields of the planet. The former is dipole-like, filling a doughnut-shaped volume about the planet. The latter is disk-like, extending far out into space. One conclusion from study of the Pioneer 10 encounter data is that Jupiter spins off high-energy particles from the circumference of the rotating outer radiation belt. These particles were detected by on-board instruments when the probe was well out from the planet, several days before the first crossing of the bow shock wave. It now appears (by hindsight) that these particles were detected some time ago by instruments on Earth-orbiting satellites. It had previously been supposed that the Sun was the only source of such particles in the solar system.

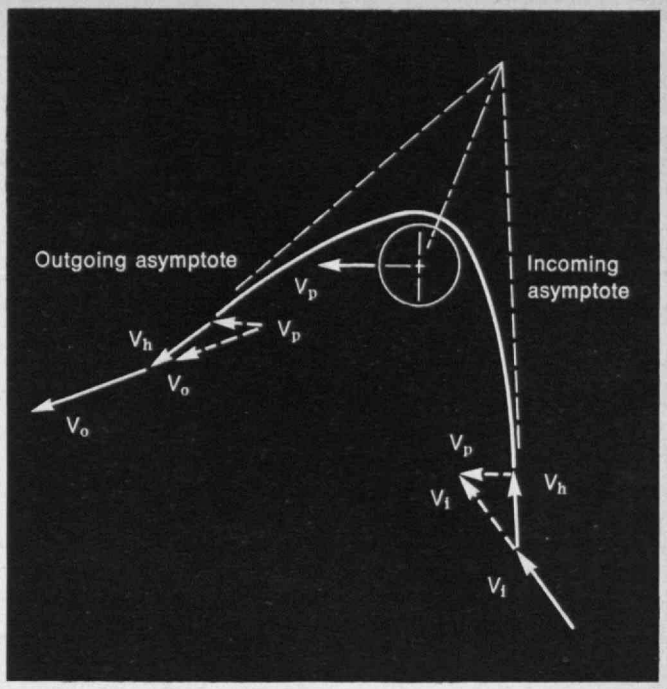
Pioneer 10 received total radiation amounting to 100 times the lethal dose for humans as it flew by Jupiter at its closest approach—about 200,000 km. from the center of the planet. Some on-board equipment malfunctioned during the encounter, but most of it returned to useful operating condition afterward. Pioneer 11 will pass much closer, within about 110,000 km. of the center. However can it survive? The saving grace for that probe lies in the fact that its different encounter trajectory results in less time being spent in Jupiter's intense radiation belts.

Radio astronomers had long been aware that there were correlations between some features of the high-frequency radiation (5 to 40 MHz) from Jupiter and the relative orientations of Earth, Jupiter, and Io. Pioneer 10 showed that the inner satellites of Jupiter (the four Galilean moons plus a tiny, closer-in one, all within the magnetosphere of the planet) produce other unusual effects. By sweeping up charged particles, they clean portions of Jupiter's belts of trapped radiation. Io appears to travel in an orbit-like doughnut of hydrogen. There has been no opportunity to observe such things before: The Earth's Moon remains far outside its magnetosphere, so cannot interact with it; Mars has no magnetosphere for its two tiny moons to affect; and Venus and Mercury have neither magnetospheres nor moons.

The new observations indicate that Io (in particular) affects the environment of Jupiter in many ways, some of which may be far more significant than the mass ratio (1:20,000) between this moon and the planet might indicate. That emerging conclusion opens up a host of novel possibilities, some of which are disturbing. We seem to be compelled by factual evidence and scientific logic to admit that some apparently inconsequential causes (such as Jupiter's moons) can exert marked influences on very large effects (the environment of the planet). Can we abruptly dismiss as balderdash the recent suggestion of John Gribbin and Stephen Plagemann (*see their book,* The Jupiter Effect: The Planets as Triggers of Devastating Earthquakes, *New York: Walker and Co., 1974*) that a particular alignment of Sun, Earth, Jupiter, and other planets in 1982 will affect sunspots, disturb the solar wind, and trigger the release of strain energy along terrestrial earthquake faults?

III. Beyond Jupiter

A full ten years before Pioneer 10 flew by Jupiter, it was proposed to use the gravitational field of a planet



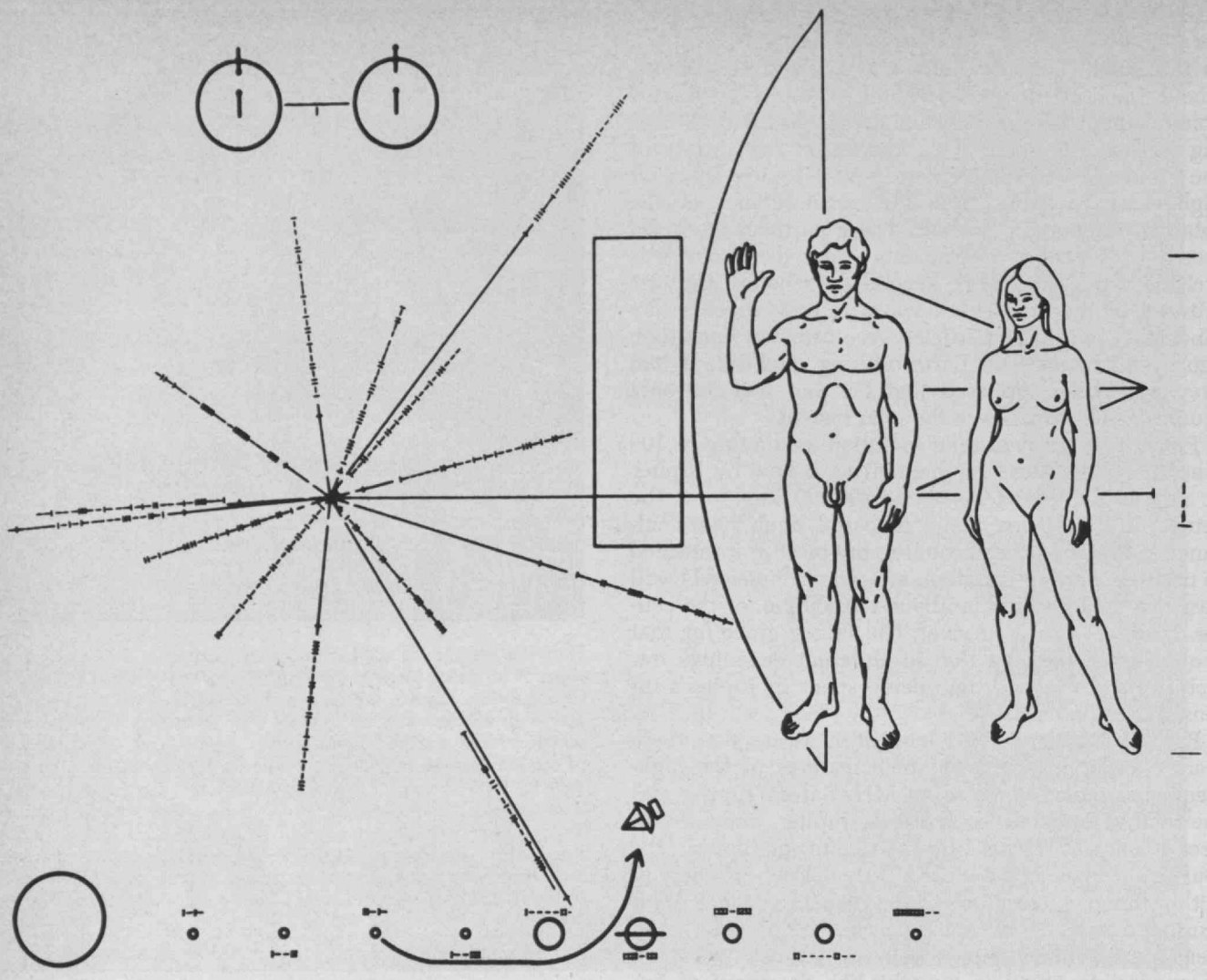
Here is a diagram of what the author describes as the "elegant" concept for using planetary gravity to accelerate a spacecraft during fly-by. Assume the spacecraft approaches the planet from afar with an inertial vector velocity V_i with respect to the Sun, which is far below the bottom of the diagram. The velocity of the planet with respect to the Sun is V_p. The spacecraft has velocity V_h with respect to a planet-fixed inertial reference plane. The spacecraft swings by in a hyperbolic orbit, departing toward an asymptote with the same limiting speed $|V_h|$ as it approached the planet. Its velocity is in a different direction, however; switching back to the sun-fixed reference frame, the magnitude $|V_o|$ of the resulting velocity is found to be significantly larger than $|V_i|$.

to accelerate a spacecraft and thus to shorten its travel time from Earth to the outer planets. The departure direction and speed are determined by the chosen direction and speed of approach to the planet and by the selected closeness of approach midway through the encounter. On the basis of Pioneer 10's planned trajectory, a calculation showed that the speed multiplication as a result of Jupiter's gravitational field would approach a doubling.

(For those readers whose consciences are troubled by conservation of this-and-that and who wonder if there is some fallacy in the argument, it can be said that a full-blown treatment of the problem discloses a slowing-down of Jupiter to counterbalance the speeding-up of the spacecraft.)

The maneuver worked in the case of Pioneer 10 just as classical mechanics said it must, and the spacecraft is now en route to the limits of the solar system and beyond. Nor is it likely to be the last use of Jupiter as an accelerating way station for probes to the outer planets, for there are distinct benefits in terms of increased payload and decreased travel time.

Pioneer 11, however, will not fly by Jupiter in a classic speed-gaining "slingshot" maneuver. Instead, it has been specially targeted to lose speed in its encounter with Jovian gravity and depart on a trajectory that will send it back to within three solar distances of Earth and thence to a rendezvous with Saturn in 1979. The



Even after its power is exhausted, Pioneer 10—sailing through the universe beyond the solar system—will have a message for anyone or anything that finds it: this plaque which tries to describe Pioneer's origin in a universal language. In the upper left is a symbolic representation of the ground-state resonance of the neutral hydrogen atom. The frequency of that resonance (about 1420 MHz.) and its free-space wavelength (about 20 cm.), says the author, "can plausibly be considered universally recognized bases of measurement"—among the first quantities a civilization would be likely to determine when it develops electronic science and radio astronomy. In addition, the 1420-MHz. area is an optimal spectral region for interstellar communication. The radiating lines represent the positions of 14 pulsars as seen from Earth, arranged to indicate our Sun as the center of the launching civilization and the time in pulsar history when the spacecraft was launched. At the bottom is the Pioneer trajectory among the Sun and planets of our solar system.

encounter phase of that mission will be challenging. The round-trip travel time for radio communication will be almost three hours. There will have to be some significant ground-terminal improvements to provide a 1,024 bit/sec. telemetry data link at encounter. Most important, Pioneer 11 must continue to work well 6.5 years after its launch. There is optimism for all this. In fact, some mission planners are sufficiently audacious as to imagine threading Pioneer 11's trajectory through one of the gaps in Saturn's rings.

This discussion of the "slingshot" maneuver brings to mind the proposed (and passed-over) Grand Tour of the outer planets. This extraordinary mission (which would have to be launched in 1977, with a second opportunity in 1978) would have swung by Jupiter (about 4 A.U. from Earth; an A.U., or Astronomical Unit, is equal to the distance between Earth and Sun, about 150 million km.) in 1979, by Saturn (about 10 A.U. away) in 1981, by Uranus (about 19 A.U.) in 1985, and by Neptune (about 30 A.U.) in 1989. Another such launch opportunity will not occur until 2152, and each 175 years thereafter. The uniqueness of this mission (one worthy of Minnesota Fats) was fully appreciated. N.A.S.A. decided to forego it. There were two powerful and independent arguments against it:

—The scientific community did not support the Grand Tour. The Space Science Board of the National Research Council concluded in 1970 that the mission would use resources that could otherwise be applied to several less ambitious missions, the collective scientific value of which would be higher than the Grand Tour by itself.

—There was grave doubt in the engineering community about the feasibility of launching in 1977 a

large, complex spacecraft that would perform reliably for 12 years thereafter.

The result was that N.A.S.A. continued on a multiple-mission program for the exploration of the outer planets. Pioneers 10 and 11 were the first launches in that program. The success of these missions, together with the information they have returned about the interplanetary and Jovian environments, will contribute to the design of the two Mariner Jupiter/Saturn spacecraft now under development. Those vehicles (to be launched in 1977) will fly by Saturn in 1981. Other outer-planet missions are under study.

The Journey to Infinity

A few years from now, Pioneers 10 and 11 will have left the solar system far behind. (Pioneer 10 is headed generally toward the star Aldebaran in the constellation Taurus, 68 light-years away.) Assuming that the available power from the RTGs continues to drop linearly with time, both spacecraft will be out of electrical energy late in the 1980s. They will have been unable to communicate with Earth for several years before then.

Something has been done, however, to give the Pioneers a possible usefulness after that time. For each spacecraft carries a small engraved plaque, placed so that it won't be scoured by interstellar dust, to carry an explanatory message to anyone or anything that finds it.

The likelihood of either probe ever being noticed, gently intercepted, and examined is very small indeed, but the plaques cost only 0.3 lb. each in payload weight and produced only a handful of letters to newspapers and magazines complaining about the frontal nudity of the humans portrayed. Some features of the message are obvious (the outlines of the spacecraft, for example, which show the scale of the human figures and indicate the solar-system origin of the probe). Others (the encoding of the epoch of launch in terms of pulsar frequencies as observed from the solar system) will be more of a challenge, but any extra-terrestrial agency capable of collecting the plaque in the first place surely must have the intellectual horsepower to spare for such tasks.

IV. How Much, and Why?

Our account of these missions would be incomplete if we did not attempt to reckon their cost. The numbers given here have been collected from several sources and are in no sense official. Important economic and accounting factors have been ignored for simplicity. Most of these dollars were not the inflated dollars of 1974. With these caveats, then, here is one set of estimates:

N.A.S.A.'s line-item cost for the program was $99.9 million. That figure covered the procurement of two spacecraft, two sets of science-experiment packages, and one set of RTGs, support for operation of the Deep Space Network and for the reduction and analysis of the scientific data by various investigators, and the cost for N.A.S.A.'s Ames Research Center to manage the program. Had there been only one Pioneer sent to Jupiter the line-item figure could not have been halved, for the cost of the basic design and development efforts would be undiminished.

The two Atlas-Centaur rockets with special third stages may have cost a total of $33 million. The A.E.C. carried the RTG program (design and provision to N.A.S.A. of a second set of flight units) at $6.8 million.

Adding it all up, we get about $140 million; each mission may therefore be said to have cost each U.S. citizen 25 cents. It has been estimated that the Pioneer 10/11 program represents 15 million person-hours of effort, equivalent to 7,500 person-years (50 40-hour weeks per year) or to 250 30-year person-careers.

Why did the U.S.A. spend all that money for that purpose?

One answer sometimes given to questions of this sort is the mountain-climber's response: We explore Jupiter because it is there; the questing human spirit can never rest when a frontier of potential knowledge or accomplishment beckons. We must go onward, and upward, and outward.

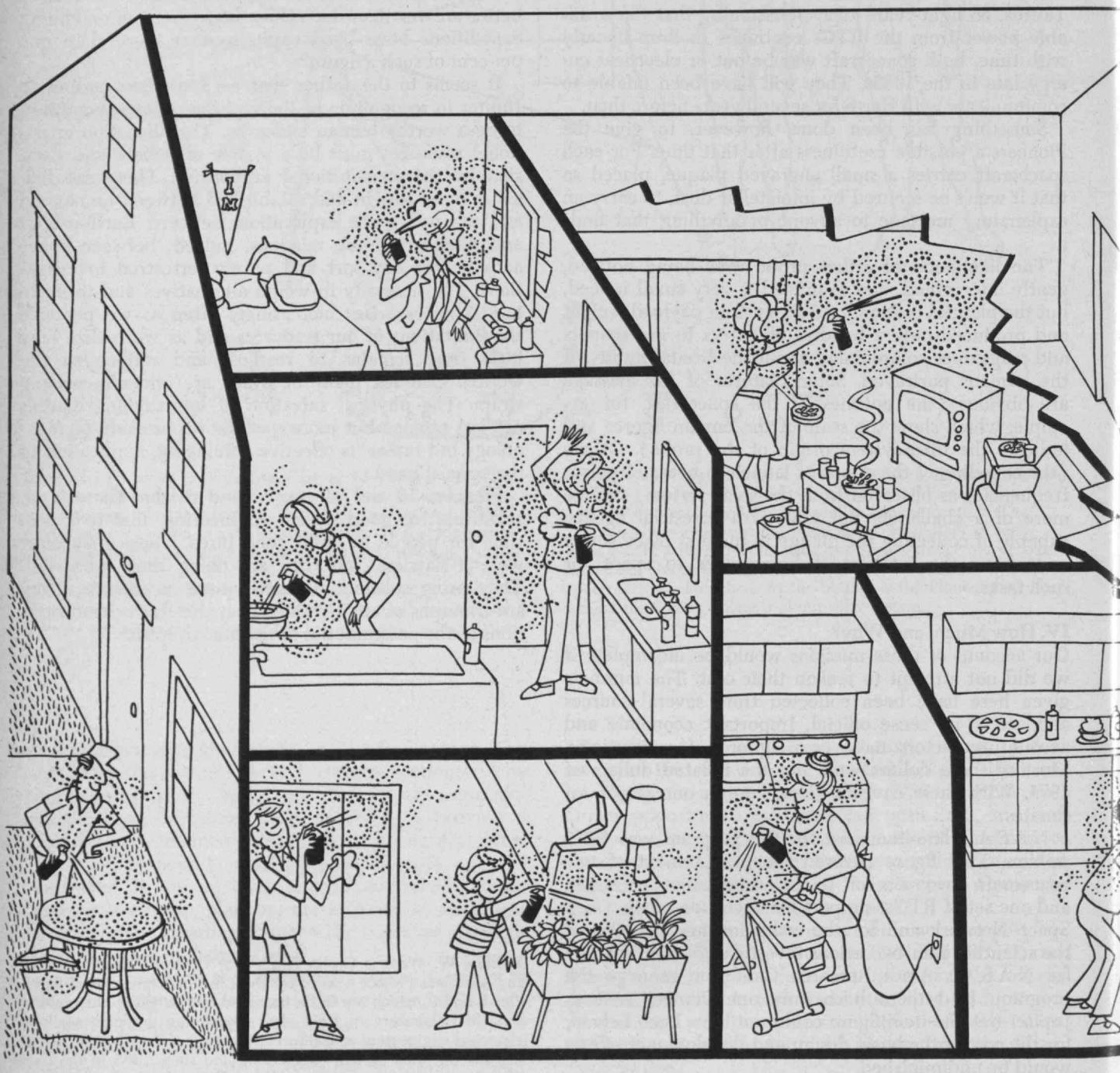
However, $140 million of public money demands a better answer than that. How many mountain-climbing expeditions have been capitalized at more than one per cent of such a figure?

It seems to the author that we sent these probes to Jupiter in recognition of the fact that science continues to be a worthy human endeavor. The allocation of national resources must be a matter of debate and decision by the constitutional authorities. There are balances to be sought and established between unmanned and manned space exploration, between Earth-orbital and planetary-probe missions, indeed, between space activities of any sort and purely terrestrial investigations. The necessity to weigh alternatives and to make hard choices arises increasingly often as we perceive the limitations of our resources and as we realize how little time remains to readjust and rationalize the world's societies, many of which are under increasing strain. The physical salvation of humankind requires not less science but more, not the suppression of technology but rather its effective, intelligent, application to the tasks at hand.

Pioneers 10 and 11 can remind us that there is no substitute for good system engineering, that it *is* possible for people to build good birds. These spacecraft weren't flawless, but they are doing their jobs well. They bring substantial contributions to science. They are triumphs of engineering. They are fresh demonstrations of the potentialities of the human spirit.

William W. Ward is Group Leader for Optical Communications and Associate Project Leader for the Lincoln Experimental Satellites 8 and 9, which are to be launched late in 1975. He came to Lincoln Laboratory in 1952 after completing graduate work in electrical engineering at California Institute of Technology, working first on radar system engineering and since 1965 in the field of space communications. A native of Texas, he studied at Texas A & M University (B.S. 1948) before going to Caltech (M.S. 1949, Ph.D. 1952).

Atmospheric scientists have recently discovered that fluorocarbons, those chemicals used as propellants in aerosol sprays, may seriously reduce ozone levels in the upper atmosphere. Ozone is the oxygen molecule which protects living things on earth from overdoses of ultraviolet rays. These findings, in combination with fears about health dangers from fluorocarbons, could be enough to shake up a $3 billion industry. Fluorocarbons alter heart rhythms and lung tissue, in large amounts perhaps fatally, according to *Consumer Reports* (May, 1974.) The propellants can also irritate the skin and help insinuate dangerous chemicals into the body through both the skin and lungs. Ingredients other than propellants may also be dangerous as part of an aerosol spray, medical experts told *Consumer Reports*. And, of course, there is the widely recognized danger of aerosol can explosions. The National Resource Defense Council has already petitioned the Federal government to outlaw such propellants. (Illustration by Roy Doty)



Trend of Affairs

Trends This Month

CHEMISTRY 61

They don't call them aerosol bombs for nothing . . . Genetic controls revealed.

NUTRITION 63

World planning to prevent triage . . . and prenatal planning to prevent infant deficiency.

TRANSPORTATION 64

More and more, let your fingers do the walking . . . Ocean ports may need retrofitting . . . Better jets than turboprops.

COMPUTERS 67

A machine that reads out loud . . . Two may keep a secret if neither is a computer . . . Computers may tip the balance of power . . . but they can't change our children's heredity.

BIOLOGY 69

How drugs act on the brain.

CHEMISTRY

From Under Arms to Upper Atmosphere

Aerosol sprays not only destroy dirt, odors and insects, but also could destroy the protective stratospheric ozone layer that shields the earth from an overdose of ultraviolet rays, it was announced this fall at the annual meeting of the American Chemical Society.

Spray can propellants—also used in refrigerants, solvents, lubricants and plastics—are polyhalogenated derivatives of methane and ethane, containing fluorine, and in most cases chlorine or bromine. These fluorocarbons, as as they are commonly called, have the commercial advantages of nonflammability and extreme biostability. It is this very chemical stability, however, that makes them so dangerous.

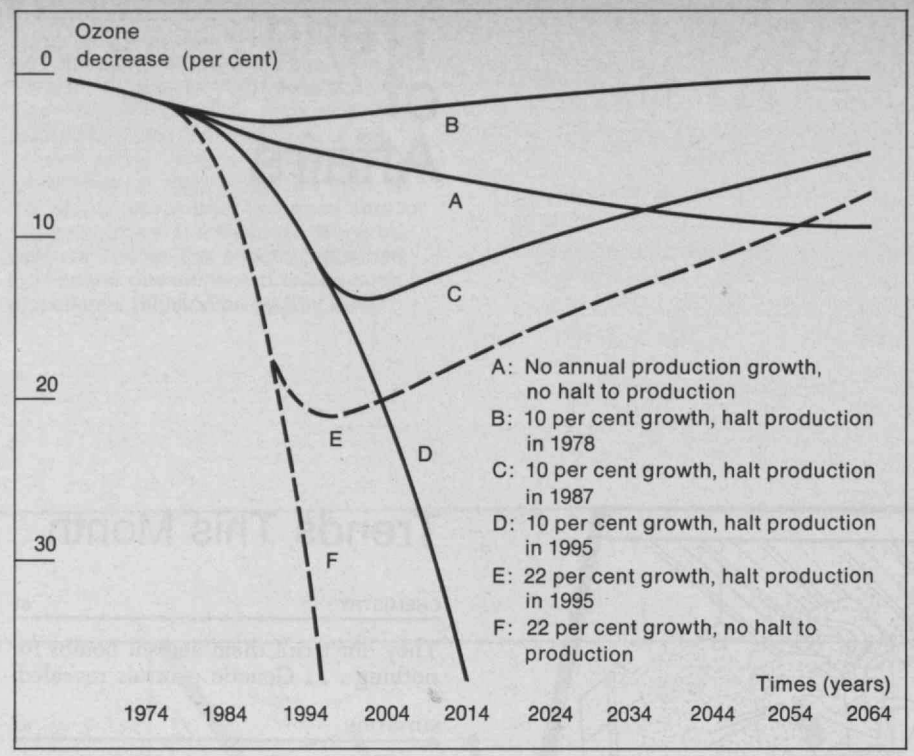
Measurements of the atmospheric fluorocarbon levels in the last three years have revealed steadily rising concentrations, going from approximately 52 parts per trillion to about 85 parts per trillion. "From this limited data, one can only speculate as to the steady buildup of fluorocarbons in the atmosphere," said Dr. J. W. Swinnterton of the Naval Research Laboratory, who performed most of the measurements. The amount of fluorocarbons in the lower atmosphere "is about equal to the amount manufactured so far, which means these chemicals are not absorbed by natural sinks, such as rainfall, which control the levels of most other chemicals in the environment," according to F. S. Rowland, Professor of Chemistry at the University of California at Irvine.

If fluorocarbons are neither biodegradable nor washed away, what happens to them? Theory has it that they are carried upward through the atmospheric layers by wind currents, and eventually arrive intact in the stratosphere. In 50 years, all the fluorocarbons now floating freely close to the earth will have been carried to an area between 20 and 30 miles above the

earth, said the scientists. Here the fluorocarbons will finally be broken down by the action of sunlight—unfortunately freeing a chlorine atom that reacts catalytically, and repeatedly, with ozone molecules and destroys them. Dr. Rowland calculates a resulting decrease in ozone of 10 per cent or more, a dent in the earth's ultraviolet shield sufficient to cause deleterious effects on plant and animal life.

Further complicating the situation is the possibility that the ozone layer would be shifted in its distribution with altitude. Since absorption of radiation by ozone is the main control of the stratospheric temperature structure, the alteration of the ozone distribution would certainly alter the temperature structure. "The ultimate effects of a different temperature structure, in terms of climate alteration, are simply unknown," said Dr. Rowland.

In deciding the future of fluorocarbons in industry, the commercial and technological advantages which have encouraged their production—more than 800 million pounds last year—to increase nine per cent per year must be weighed against the long term biological, medical, and climatological risks attendant upon their continued use. Dr. Rowland's opinion is that "the advantages of the former are not worth the risks of the latter."



OMINOUS OZONE OUTLOOK: A Harvard University computer analysis of the effects of fluorocarbon aerosol chemicals on the ozone of the upper atmosphere forecasts serious reductions of protective ozone for all but the most stringent policies of production curtailment.

A team of Harvard University scientists has performed a more sophisticated analysis of fluorocarbon ozone effects, to be published in an upcoming issue of *Science*. Their analysis, which considered additional factors of atmospheric mixing and chemical reaction, led to even more pessimistic conclusions than previous studies. The Harvard scientists—Michael B. McElroy, Steven C. Wofsy and Nien Dak Sze—postulated six possible approaches with respect to fluorocarbon manufacture and modeled the atmospheric effects of each. The approaches included a no-growth, no-production-halt model, moderate growth, eventual-production-halt models, and models featuring a continuation of the present 22 per cent annual growth in production. Their computer methods, when used in other studies of the effects of SST exhausts on the ozone layer, showed excellent agreement with actual atmospheric observations, the scientists said.

The results showed decreases in ozone above 10 per cent for all but the most conservative of policies.

So far, reaction to findings of fluorocarbon effects have been cautious. A National Academy of Sciences study committee has been formed including many of the atmospheric scientists who have voiced concern over the hazards of fluorocarbon use. The committee will meet to decide whether to form a permanent committee of the National Research Council—the research arm of the N.A.S.—to oversee research on the problem. Another N.A.S. group, the climatic impact committee, is already immersed in studying fluorocarbon effects as part of its general assessment of pollutant effects on the atmosphere.—*S.J.N.*

Traffic Signals of Life

Puzzling out the code by which the living cell translates genetic information into functioning proteins was certainly a landmark in man's understanding of biology. But in terms of the discoveries yet to be made about how the cell controls this translation, even the monumental "unraveling of the genetic code," as it is popularly known, will be a mere footnote.

Look at the record. The living cell devotes the great majority of its genetic material—some have estimated 95 per cent—not to blueprinting protein molecules, but to controlling the reading of those blueprints. To the living cell, as to the human being, it takes more to govern when, where, and how much than it does to govern what to do.

Control of the expression of genes is probably governed overall by complex mechanisms involving many genes and control signals; but also vital are the individual start and stop signals on either end of each linear gene. The enzyme which transcribes genetic information from DNA onto messenger RNA somehow recognizes these start and stop signals and turns itself on and off in response to them. Genetic information in the cell flows from DNA to RNA, which then builds proteins that, as enzymes, perform the chemical work of running the cell.

Dr. Har Gobind Khorana, 1968 Nobel Laureate for work on elucidating the genetic code, announced at the annual meeting of the American Chemical Society this fall that he had determined the sequences of the start and stop signals for a man-made gene he and his co-workers had already synthesized. A colleague of the M.I.T. professor of biology—Dr. Ramamoorthy Belagaje—reported in another paper that work was underway to build the signals and attach them to the artificial gene. With this achievement the scientists could study for the first time precisely how the cell starts and stops its genes, both in the test tube, and, more spectacularly, in the living bacterium.

The gene, found naturally in the human gut bacterium *Escherichia coli*, codes for the molecule tryosine transfer RNA—the component of the protein synthesizing machinery which

fetches the amino acid tryosine to the protein-building site to be incorporated into the protein molecule. Like all genes, the gene for tyrosine transfer RNA is a linear string of a specific sequence of four kinds of nucleotides—adenine, guanine, cytosine, and thymine. Dr. Khorana's gene is 126 nucleotides long, and the start and stop signals were found to be, respectively, 29 and 22 nucleotides long. These are the sequence lengths which the scientists believe encompass the entire signals, but only further testing will tell if the scientists do indeed have the entire control signals.

Perhaps most significantly, the biologists discerned "areas of symmetry" in the signals which do not exist in genes themselves. In other words, the nucleotide sequence along one stretch of a signal complements the sequence along another stretch. Since nucleotides in DNA tend to pair up due to mutually attractive chemical forms—adenine with thymine, guanine with cytosine—such symmetry might mean the signals are folded in nature—one area pairing with another further along the linear. Such puckered DNA would offer a recognizable shape to a synthesizing enzyme as a start or stop signal.

The scientists will study the functioning of the gene and its signals, once it has functioned properly, by substituting different nucleotides at various points in the sequence and examining how those substitutions affect transcription.—*D.M.*

NUTRITION

"The Coldest, Nastiest Decisions in History"

The National Academy of Sciences and its associated National Research Council may well represent "the world's largest consulting firm," outstanding not only for the distinction of its consultants but also for the fact that they are unpaid. But its President is troubled: Even this most distinguished body of scientists is not really prepared—certainly not yet organized—to confront what he considers "the most important questions of our time."

We use buzz words, like "population" and "food" and "resources," said Philip Handler, President of the Academy, at the annual luncheon of the M.I.T. Corporation this fall. But we lack "a rational, sensible, and coherent way" to deal with the problems of growth.

We understand only in theory that the United States cannot help every nation that seeks our help—or will soon do so. If we try to sustain the world's population by sharing "equitably" our modest wealth of food and medicine, the result may well be counterproductive and only prolong the agony of countless underdeveloped people with gradually diminishing supplies of such elemental needs as food and shelter. The only obvious alternative is to try to discover how the limited resources we can provide will be used with best effect, leaving others to some variant of Aristotle's advice: "From time to time it is necessary that famine, and pestilence and war prune the growth of the human race."

We face what Dr. Handler fears must be "the coldest, nastiest decisions in the history of the human race," and we have no idea how to make them.—*J.M.*

New Priorities for Nutrition

Whether or not you foresee a coming "food crisis" (*see pp. 12-19*) the fight against malnutrition is now becoming a new ball game. Nutritionists no longer need feel they are "walking up the down escalator"; "substantial" resources to fight malnutrition are finally available, and now the primary issue is "the unruly problem of priorities," thinks Alan Berg, Deputy Director for Population and Nutrition Projects at the World Bank.

If resources are no longer a constraint, why are there so many hungry people? Here is a list of new priorities from speakers at an M.I.T. summer symposium to honor Dr. Carl Taylor, Chairman of the Department of International Health in the Johns Hopkins School of Public Health:

—Let nutritionists "infiltrate" the fields of agricultural and economic policy-making. That's not often done today, and what happens on farms and in people's pocketbooks clearly affects the kind of food people eat.

—Let planning be systematic, realistic, and courageous. The time has come to move beyond research and pilot-plants in international nutrition.

—Concentrate help where it's really needed—among the very poor in the underdeveloped countries. Many nutrition programs dedicated to helping the poor have helped the not-so-poor, especially in countries where "even the rich are poor," said Dr. Michael Latham, Professor of International Nutrition at Cornell. "A major, chronic problem," he thinks, and hard to solve because the poor are by far the hardest part of any population to reach.

—Find and publicize some "success" stories—examples of how nutritional intervention has in fact improved the health and quality of impoverished people's lives, suggests Dr. F. James Levinson, Director of M.I.T.'s International Nutrition Planning Program which sponsored the seminar. A footnote from Dr. Nevin S. Scrimshaw, Head of the M.I.T. Department of Nutrition and Food Science: don't be disillusioned by some past programs which may have seemed to fail because they did not fulfill all of the great national needs. Even if it didn't win the confidence of every mother, Incaparina, the low-cost protein supplement which Dr. Scrimshaw and his associates introduced in Central America, is used by thousands and thousands of families whose children would otherwise be victims of protein deficiency.

—What about the ethical issues? A "growing callousness" towards food problems is in fact Dr. Taylor's greatest concern. There is callousness in the U.S. about the nutritional needs of our under-privileged, and selfish callousness in other countries has localized famines and jeopardized the distribution of what relief supplies may be available. In times of crisis, dare we imagine that countries with ample food will share with those in famine? Will the U.S. continue its "overconsumption" of protein grains (in the form of beef) at the expense of peoples to whom even wheat is now denied?

—Nutritionists should be propagandists as well as scientists, thinks Dr. Scrimshaw. The real need is to reduce nutrition to the simplest terms. To write theoretical papers and make endless population studies may be as callous and elitist as eating food instead of sending it to people who need it.—*J.M.*

Invisible Deficiency Endangers Unborn

The fetus, suspended in its water-cushioned sac, was always thought to be a perfect parasite that extracted needed nutrients from its mother's bloodstream and prospered with little regard for external circumstances. Only severe maternal nutritional deficiencies could harm the unborn, contended nutritionists; proper maternal nutrition was not difficult to come by.

But now, disturbing findings by M.I.T. Professor of Nutrition and Food Science, Paul M. Newberne, seem to show that an invisible deficiency, so subtle as to go unnoticed in a pregnant woman or her offspring, can have undetected, insidious effects on a child's ability to ward off disease. The effects may not show up for years.

The particular substances whose lack makes for such a "nutritional time bomb" are the lipotropes—a class of

chemicals including vitamin B-12, folic acid, choline and methionine. These interrelated chemicals participate in biological reactions vital to the development of the body's immune system, part of which is controlled by the thymus gland.

Dr. Newberne and his colleagues say their research with mother rats and their offspring over the last few years reveals that even marginal deprivations of these substances cause possibly irreversible damage to an offspring's thymic-mediated immune system. Although the research has been principally with rats, some studies have shown humans to be similarly vulnerable; and in any case, rats and humans are in many respects very similar biochemically.

Most disturbing are nutritional surveys showing that a significant percentage of the pregnant women in this country possesses below-normal levels of folic acid. Because of hormonal effects on folic acid levels, birth control pills are a common cause of deficiency in folic acid.

The experiments consist of restricting the levels of lipotropes—principally folic acid and methionine—in the diets of pregnant rats, and then examining the effects on the offspring's ability to overcome a common food-poisoning bacterium, *Salmonella typhimurium*. The scientists found that the offspring of such marginally-deprived rats died in significantly greater numbers from the food bacterium than did offspring of adequately fed animals. Otherwise, the affected rats gained weight and developed as normally as other rats.

The evidence indicates that the damage to the offspring occurred in the womb—for when the researchers fed maternally deprived offspring adequate lipotrope diets, their resistance to infection still did not improve. And the mothers had been given adequate lipotropes after birth, so that the nutrition of the nursing offspring was not affected.

Examination of the affected offspring revealed smaller thymus glands than usual, with fewer cells. In test tube cultures, thymic-dependent lymphocytes from affected offspring functioned only about one-third as well as those of normal rats. The thymus, one of the central controls of the body's immune system, is relatively large in relation to body size during fetal life and the first years after birth. A small gland high in the chest, it increases in size until adolescence and then begins to atrophy. The thymus liberates a chemical factor early in life that stimulates the body's lymphatic system to produce infection-fighting lymphocytes. The gland also processes cells sent from the bone marrow, endowing them with special immune capabilities in local cells and sending them on to lymph nodes and the spleen.

These studies, and others showing that humans deprived of lipotropes also suffered depressed immune responses of the type controlled by the thymus, have moved the M.I.T. researchers to call for a program to prevent lipotrope deficiency in pregnant women. In Great Britain obstetricians automatically provide pregnant women with folic acid pills. In the U.S., not only is folic acid not included in maternal vitamin supplements, but it is a prescription item since its use may mask the effects of pernicious anemia.

One avenue of future research, says Dr. Newberne, will be the role of lipotrope deficiencies in increasing vulnerability to cancers, since the thymic-dependent immune system is also responsible for fighting off proliferating cancer cells. The scientists have already discovered that animals whose mothers were marginally deficient in lipotropes are, indeed, more susceptible than others to certain carcinogens.—*D.M.*

TRANSPORTATION

Is This Trip Really Necessary?

Since the new goddess of transportation—mass transit—began to replace the previous deity—the automobile—industry and government have pointed with considerable pride to the new transit systems they are spawning.

Their efforts at improving transportation efficiency, and reducing congestion and pollution via mass transit, are certainly commendable. But in a sense the Urban Mass Transportation Administration (U.M.T.A.) and the Environmental Protection Agency have "just kept rolling along"—producing plans for new transit systems with no study of the alternative of reducing urban travel.

Several recent studies have emphasized this lack, concluding that Americans can significantly reduce the massive 25 per cent of the nation's energy budget devoted to transportation by rejiggering the American way of life.

The most comprehensive study, performed by researchers at the INTERPLAN Corporation in Santa Barbara, California for the U.M.T.A., was published this fall under the title "Reducing the Need for Travel." The researchers, Dr. Roman Krzyczkowski and Suzanne S. Henneman, contend that a combination of communications substitutes, land use changes, and rescheduling of work activities could yield a 3 per cent reduction in travel within one to three years, and over the next 20 years or so could reduce total travel by one-seventh. They emphasize that their figures are conservative, and that reduced energy supplies, increased energy costs and anti-travel publicity campaigns could easily generate even more dramatic reductions.

They first analyzed the reasons urbanites travel 1.3 million vehicle miles per day. Predictably they found that 42 per cent of the mileage was for work and business purposes. Social and recreational purposes consumed 33 per cent of the mileage, and considerably lesser amounts were taken up by shopping, and other personal business and educational, civic or religious purposes. From 85 to 98 per cent of all this travel was by car—proportions that will probably persist despite mass transit improvements. Thus, reducing the need for travel will dramatically reduce the inefficient use of petroleum and materials attributed to the automobile.

The communications substitutes for travel envisioned by the researchers range from the commonplace, such as the telephone, to the futuristic—two-way videophones with facsimile transmission capabilities. Surveys of experiments in such communications technologies lead the INTERPLAN researchers to predict that "because of the cost and bandwidth limitations in the immediate future, one should look forward first to marginal improvements of existing telephone systems." The likely consequences of more widespread availability are: improved (and cheaper) telephone conference calls, loudspeaker equipped telephones, facsimile terminals, audio conference systems, remote drawing systems, video display terminals, and slow-scan video graphics systems." Drastic reductions in cost are expected in the long run because the efficiency afforded by high-capacity laser-beam transmission will give business and industry even more options to substitute information-moving for people-moving.

But what percentage of the work force could be expected to take advantage of these systems, and conduct their business at home rather than in central offices? About 50 per cent of the work force are white collar workers, and could conceivably do all or part of their work at home, given the right communications devices. Blue-collar workers and service workers would still have to travel because their physical presence is required for their jobs. The INTERPLAN researchers estimate that advanced communications could reduce the number of trips to and from jobs by 16.6 million. This represents the elimination of about 7.5 million cars from the roadway daily, equivalent to the present total annual pro-

Urban Mass Transportation Administration's SUBWAY CAR OF THE FUTURE. Being built under an $8 million contract from the federal government to Garrett AiResearch Manufacturing Co., this Advanced Concept Train will utilize such futuristic ideas as energy-storing flywheels. The flywheels spin to soak up energy normally released as heat when the car brakes, then release it into the wheels as the car accelerates. Such advanced concepts may one day improve mass transit, but has the U.M.T.A. neglected ways to reduce the need for travel in the first place?

duction of the U.S. automobile industry.

Improved communications devices in the home would also substitute for 50 per cent of shopping trips, 25 per cent of educational, civic or religious trips, and even 5 per cent of medical and dental trips, concluded the researchers.

Krzyckowski and Henneman doubt that rearrangement of the city structure could have much impact on travel reduction. For instance, planners might intermingle work and living areas in hopes that people would live near their jobs. However, a recent poll revealed that only 8 per cent of working men and 4 per cent of working women would like to work closer to home, and most people would prefer to live as far from their jobs as always.

Another means for reducing travel examined in the study was work rescheduling, such as the four-day 40-hour week, or staggered working hours. A four-day work week, for instance, could eliminate 20 per cent of commuting trips, although a worker's day off might be spent in pleasure traveling. The researchers suggested such schemes be given high priority, because of their relative ease of introduction, and their tendency to reduce travel loads during peak hours.

Further, INTERPLAN researchers propose a campaign to "re-educate the public to drive less." With a slogan similar to that used in Britain during World War II fuel scarcities—"Is Your Journey Really Necessary?"—such a campaign would not only reduce travel, but could increase demand for such advanced communications services. The campaign could sharpen demand for communications advances even more by producing scenarios on television or other media of what life could be like with videophones or a home computer attached to a television.

Among the complexities of substituting communications for travel are the vagaries of accurately measuring energy savings. Not only the direct energy used by a trip or a telecommunications call, but also "overhead" energy used in building and maintaining the systems, and even the "real" amount of energy taking conversion efficiencies into account must be measured. British scientists Roger Pye, Michael Tyler and Brian Cartwright reported one such attempt at analysis in the September 12 *New Scientist*. They find that using a video conference system instead of traveling to a meeting can save up to 200 kilowatt hours for each person at the meeting, assuming a distance traveled of 400 miles. This analysis considers the total energy needed to run a videophone system with present technology; the energy savings promises to be even greater as communications technology becomes more sophisticated. Preliminary findings of more in-depth analyses indicate that telecommunications remains the least energy consumptive, even with overhead costs added, say the scientists.

As with any social innovation, such communications-for-travel substitutions raise the possibility of future shock. Though jobs and shopping chores might be performed electronically, will people welcome the prospect of losing their present mobility—their "America-on-wheels" freedom? Perhaps workers will mourn the loss of social stimulation of face-to-face contact afforded by office jobs. Indeed, psychological studies have consistently revealed that the social interaction at work ranks high on a worker's list of considerations.—*D.M.*

Toward a New Age of Specialty Ports

Seaports on the U.S. East Coast have grown like topsy, new facilities added as local needs were perceived and capital available. The result, says Ernst G. Frankel, Professor of Marine Systems at M.I.T., is an "enormous imbalance" in the distribution of facilities for handling different forms of cargo, a vast oversupply of general cargo docks and more modest surplus of containerized cargo terminals.

Meanwhile, changing technology is rendering most existing port facilities obsolete; for many there is "no chance of recuperating operational effectiveness unless changes reflecting future requirements are implemented without delay." If present trends continue and ports continue to atrophy, thinks Professor Frankel, increased shipping costs are inevitable and the consequences cannot help but affect the standard of living, employment level, and economic growth of the U.S. East Coast.

Here is a summary of findings by Professor Frankel after an intensive survey of all East Coast port facilities:

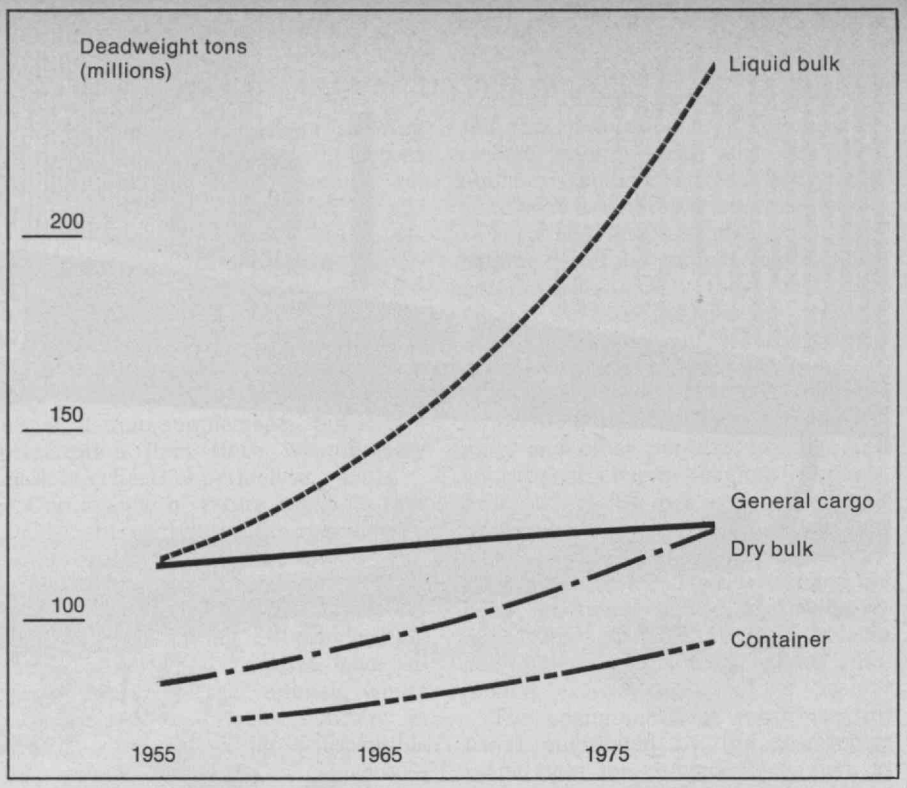
—Total general cargo through East Coast ports may be 32 million tons in 1975, rising to 34 million tons in 1980. But port capacity for such cargo is well over double these figures; there is "appreciable overcapacity," he says.

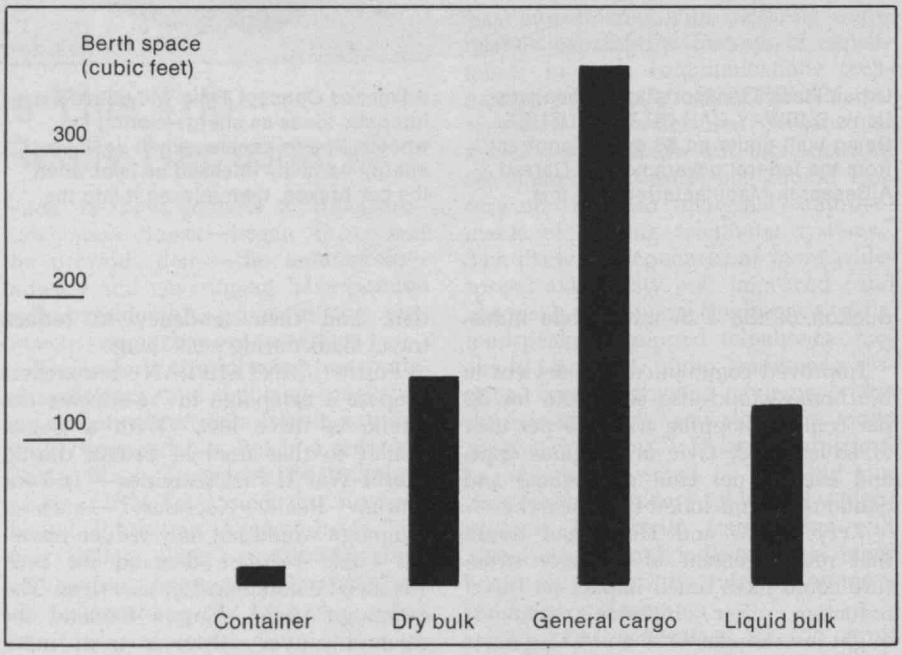
—Container cargo was 11.3 million tons in 1969 and may grow to 16.8 million tons by 1980. But this is well below the present and projected container capacity of U.S. East Coast ports.

—Dry bulk cargo is the fastest-growing component of East Coast shipping, responding to "radical" technological change which has made possible larger ships and faster loading and unloading in the 1960s. Taken by volume alone, Atlantic ports still have adequate bulk-dry-cargo capacity, but the economy of existing facilities is unattractive for the medium- and long-term future and perhaps even for the present.

—Liquid bulk cargo—mostly petroleum—presents the largest immediate need. By 1975 the cost of using existing port facilities instead of new ones which would accommodate today's very large tankers may be $500 million a year, a figure large enough so that the U.S. must give "serious consideration to deep-draft tanker terminals," writes Professor Frankel.

But such a cargo-by-cargo analysis fails to tell the story. In the past traditional ports have survived because of their diversity—many commodities could be handled, though none with optimum efficiency—and because they served industry clustered close around. Now new technology emphasizes economics of scale in shipping and cargo transfer and industry is dispersed; needs are different. Thus, says Professor Frankel, "modern port technology favors large single- or limited-purpose facilities with throughputs greatly surpassing those of a conventional port." And for any area to benefit from the complete spectrum of port facilities it needs, regional or national port planning now appears to him essential.—*J.M.*





Specialized ships require specialized ports, says Professor Ernst G. Frankel, Director of M.I.T.'s Commodity Transportation and Economic Development Laboratory. General cargo vessels are the slowest-growing class of freighters, and the obsolescence of East Coast harbors is revealed by the preponderance of general-cargo facilities which they offer. In a recent report for the M.I.T. Sea Grant Program, Professor Frankel calls for regional and national planning to develop needed new facilities.

200 Jets for Your Civic Pride?

If you have an empty airframe factory, a few unemployed engineers, and a way to finance $6 million or so of development costs, consider this: the Flight Transportation Laboratory at M I.T., after a one-year computerized analysis of airline requirements and preferences sponsored by N.A.S.A., thinks a new 40- to 60-passenger U.S.-designed jet transport would be "a reasonable financial venture" on the basis of its potential domestic sales, and in addition it would have "considerable world-wide market potential."

But before you invest your money, be sure you have a good salesman on the staff, because you will be building an airplane that no one in the air carrier business—as of now—is sure he wants.

The eight local-service carriers now operating subsidized, scheduled services in low- and medium-density markets in the U.S.—Allegheny, Frontier, Air West, North Central, Ozark, Piedmont, Southern, and Texas International—want a new jet aircraft to replace their aging turboprops. A 30-passenger plane is sometimes too small, but they assume that a larger aircraft would be too expensive.

Some 185 commuter air carriers are now operating schedules without subsidy using aircraft with up to 30 seats and payloads of 7,500 lbs. or less. They're satisfied, in general, with their present turboprop equipment.

Based on its analysis, the Flight Transportation Laboratory agrees with the commuters; their present equipment is generally "well suited to their markets." Only a few have flights that are long enough, or crowded enough, to utilize larger or faster (jet) aircraft effectively. But "three out of four local-service carriers could replace their current turboprop equipment with a 40-passenger jet and increase their profits."

Such a plane might cost $2.5 million, including development cost pro-rated over 200 aircraft. It would attract new business to the routes on which it was flown: travel agents like to sell jets, and passengers to ride in them. In two years while Frontier Airlines changed from turbo-prop to jet equipment at Pueblo, Colorado, passenger boardings there grew 80 per cent and freight volume was up by 300 per cent.

The key factor seems to have been the Pueblo Chamber of Commerce's success in making the jets "a symbol of civic pride. People may not know whether they're on a jet or not," Walter Berry, Director of Aviation at the Pueblo airport, told the M.I.T. team. "But they know that Pueblo is a city with jet service."—*J.M.*

The Reading Machine

Arthur C. Clarke imagined it, the special effects people on *2001* produced it, and now reality has overtaken fiction—in the flat, disembodied voice of the talking computer. Dramatic but not diabolic, this computer reads aloud.

The original goal of the project, headed by Jonathan Allen, Associate Professor of Engineering at M.I.T., was to build a machine that could read to the blind. In the course of its development a much wider spectrum of application has emerged—including possible phone-in library information retrieval, new strategies of computer programming, and incredibly, new rules of English usage, syntax, and pronunciation which could be used to teach children to read.

The programmers had to teach the machine to read much as a child is taught. With the choice of either feeding the computer each separate word and all its variations—several hundred thousand words in all—or including in the program the basic rules of pronunciation, the choice was obvious.

Their job was simplified by the fact that the English language is comprised of approximately 11,000 word units, called morphs. These remain unchanged over long periods of time, and their combinations make up all words, old, new, and those not yet invented. Included in these are all prefixes, suffixes, and Latin roots. For example, the computer would see the word "unnatural" as made up of the prefix "un", the suffix "al" and the root "nature". Rules of grammar would tell that the final e had been dropped, and another set of 400 rules in the computer's memory would tell it that the vowels are soft and the correct pronunciation of the consonants—a process yielding the pronunciation of the entire word.

Other words present more of a problem, and there are exceptions to every rule. Since the word "scarcity", for example, could be divided as scar-city, scarce-ity, or scar-cite-y, a special rule instructs the computer to choose a set of word "beads" containing a prefix and suffix over a compound word. The pronunciation of the letter f, normally soft, sees its exception in the hard f of the common word "of", giving the computer another rule to digest.

Once the syllable had been conquered, the next step was to program the computer to overcome morphophonemic changes (such as the change of the s sound from "agress" to "agression") and the problem of lexical stress (such as the accent in "object" changing with its use as a noun or a verb). Sharon Hunnicutt, a member of the RLE staff, hopes to have the entire accent and stress program complete by next summer. Her work will humanize the computer voice, equipping it to show expression, rising at the end of questions and lowering at the end of declarative statements. "Currently," she said, "the computer has what sounds like a Swedish accent. You expect the voice to go down at the end of sentences, and it doesn't."

The soon-to-be-expressive voice determines what to say by reading—either words typed into its terminal or from typed sheets fed into it. At this time it is able to read only one type face, but its abilities will be expanded to include any type from any book—including chapter heads and picture captions—within two years.—*S.J.N.*

The Reading Machine's "Voice"

The reading machine has a model of the human vocal tract which lets it "speak." It does not use previously recorded words, or even previously recorded phonetic segments spliced together to form words. Such spliced-together speech sounds awkward and unnatural, and is difficult to listen to for any extended period of time.

To make speech comfortably understandable, the computer must have more control over the utterance it produces, control over such things as the duration of the phonetic segments, the pauses between phrases, and most importantly, the intonation contour of the sentence as a whole. (The technical term is "fundamental frequency".)

Humans, of course, have this sort of control. When we speak, we manipulate an air cavity in our mouth and throat. A simple analogy can be made to blowing across the mouth of a bottle, creating a low tone at a resonant frequency. If the bottle is slowly filled with water, the air space in the bottle gets smaller, and the tone gets higher and higher in frequency.

In a similar way, when we speak we rapidly change the size and shape of our vocal air cavity, and thereby change the resonant frequencies of the sounds we make. The vowel "ee" as in "peek", for instance, is made with a much smaller air cavity than the "a" in "father", and therefore has higher resonant frequencies. We excite these resonant frequencies either by frication (hissing) as in "s" and "sh", or by using our vocal chords, as in vowels. The vocal chord energy can itself be produced at different frequencies, yielding different levels of fundamental frequency, or intonation.

The vocal tract model lets the com-

puter mimic this process. For each 10 msec. segment of speech, the model (a computer program) is given such parameters as resonant frequencies, type of excitation (hissing or vocal chord), fundamental frequency, amplitude, etc. It then computes the frequency distribution of the sound which would be produced by a vocal tract with these properties. This is converted into an analog electrical signal and sent to a loudspeaker, producing "speech".

Clearly it is important to choose the correct parameters to give to the vocal tract model. The phonetic spelling provides a great deal of this information. Each phoneme is characterized by certain resonant frequencies, certain types of excitation, and a "usual" duration. In addition, however, the computer must decide which syllables receive different levels of stress. A stressed syllable tends to be longer and to have a slight rise in fundamental frequency.

Also, the computer must decide what intonation contour to give to the sentence as a whole. Most sentences tend to have a slightly falling intonation (modified by the presence of stressed syllables which produce local rises). Questions, however, often end with a rising intonation. At present, relatively little is known about such intonation contours. The group is currently working to develop rules which will allow intonation contours to be computed from a grammatical analysis of a sentence's structure.—*Perry L. Miller*

Overconfidence on Data Security?

How secure are the vast amounts of information stored and processed by computers in financial institutions?

A survey of Boston-area financial managers by Torben G. Gronning, who received a Master's degree last June from the M.I.T. Sloan School of Management, finds them generally confident—even over-confident, Mr. Gronning fears. Two-thirds of the 42 managers answering Mr. Gronning's questionnaire believe that computerization—with current safeguards—does not increase the likelihood of data disclosure. Only 27 per cent think that the chance of data destruction or modification is "considerable;" the technical managers in particular are confident of existing safeguards against both disclosure and fraud.

But computing is not a static technology, and the uses of computers by financial institutions are expanding into portfolio management; centralized credit card administration; automated cost reporting, profit planning, and incentive systems; securities transfers; and direct monetary transfers and credits. "The cashless, checkless society is slowly becoming a reality," writes Mr. Gronning, reporting in the *Sloan Management Review*.

Financial managers are indeed aware of greater risks from greater computerization of data. Almost seven out of every ten managers in the survey said their concern for data modification or destruction—the issues most likely involved in fraud and embezzlement—was either "more" or "much more" over the past three years. But they remain confident of the "extensive" protection systems which are in effect and being planned; half the managers believe that data procedures, controls, and audits now in use do a "quite" to "fully" adequate job of protection, though only one-third would admit to the same confidence in personnel precautions such as pre-employment screening, supervision, and division of responsibility.

Mr. Gronning does not share the managers' confidence; indeed, their very confidence leads him to raise "the serious question of whether managers in the financial community have anticipated adequately the changing demands for security" brought about by new computer uses.

His answer is negative: "The changes necessary to create a high degree of privacy and integrity are so fundamental and far-reaching" that they will have to come from outside the financial and computing communities. Particularly in a climate where individual rights and institutional honesty are attracting growing public attention, Mr. Gronning expects government to join manufacturers and institutions to achieve what he calls "phase two of data security."—*J.M.*

Computer: New World Force

In 1920 the balance of power among nations was measured by warships and coal, in 1940 by aircraft and petroleum, in 1960 by missiles and reactors. Will computers tip the scales of international power by 1980?

Yes, thinks Ruth M. Davis, Director of the Institute for Computer Sciences and Technology in the National Bureau of Standards. Indeed, Dr. Davis told the Congress of the International Federation of Information Processing in Stockholm this summer, "the first battles of World War III may well have occurred when mathematical formulations of strategies and counter-strategies . . . were tried out as war games on computers."

Here are some other examples of the power of computers on the international scene:

—Multinational corporations and their business transactions conducted by computers—including information and funds transfer systems—make computer technology "one of the strongest forces" to weaken political boundaries and strengthen institutional ones.

—The interchange between military and civilian technology is direct and constant in the field of computation; thus computer technology, thinks Dr. Davis, "is far less susceptible to rigid military control than more typical military technologies such as weapons systems and delivery systems."

—Many applications of computers are of international scope: boundaries are meaningless to earth resources and international telecommunications satellites, for example, and both are dependent on computers for their effectiveness.

Said Dr. Davis, "those communities, power groups, and nations using computer technology as an agent for change may be the most effective in achieving their objectives today and in the future." It is the most effective of all our technologies "for upsetting balances of power and status quos without the catastrophic effects characteristic of military technologies."—*J.M.*

Genetics: Safety In Complexity

What can a biologist concerned with genetics do with a computer?

A great deal. Modern computation has made possible much of today's molecular biology, including our understanding of the structure of proteins from amino acids and how mutations have affected evolution.

Can computers be as useful to the genetic engineer—who seeks to improve an individual or a population by changing its genetic inheritance?

The key issue to be resolved in this case, thinks Dr. Warren J. Ewens of the University of Pennsylvania, is this: because all humans look basically very much alike—two arms, two legs, five fingers—one can imagine that the changes we observe between individuals—psyche, coloring, size, etc.—are the result of changes in a very small percentage of the total genetic information base. If so, then perhaps a small part of that base can be changed to effect genetic changes that we might seek.

But it is not so, Dr. Ewens told the 1974 National Computer Conference. There is "an immense amount of genetic variation" between individuals. Indeed, he said, "we are all of us quite genetically different," and there are interactions among different genes so that changes designed to achieve one goal would have unexpected side effects.

An observation he thinks has far-reaching consequences: the likelihood of genetic engineering, by which we might manipulate genetic inheritances to reinforce certain characteristics and depress others, is beyond our power. Even given the capacity of present-day computers, he said, "the problem is simply overwhelming."—*J.M.*

BIOLOGY

The Opiate Receptor

Although man may never fully comprehend the complex functioning of his own brain, he may at least come to have a working familiarity with it—for instance, to gain enough empirical knowledge to engineer brain-affecting drugs.

A significant advance that could lead to understanding how opiates function was outlined in a lecture at M.I.T. this fall by the scientist principally responsible for discovery of the brain's opiate receptor, Dr. Solomon H. Snyder of Johns Hopkins University School of Medicine. Explaining and amplifying upon his discoveries, reported in scientific journals earlier this year, Dr. Snyder listed the reasons he believed he had isolated the actual brain receptor where opiates—morphine, heroin, etc.—bind specifically to brain cells.

One reason is that the receptor, isolated from rat brains, binds only one of the two mirror-image conformations of a narcotic molecule. Life is "life-handed," in that living creatures consist almost entirely of levorotatory molecules—those molecular forms that rotate polarized light to the left. Dr. Snyder's receptor retained only left-handed molecules, partial proof that the binding was truly biological, and not one of the many promiscuous chemical bindings that drug molecules can have for almost any substance.

Another reason for his certainty: Dr. Snyder found that a wide range of opiate drugs attach to this receptor, as evidenced by the retention of radioactively labelled drugs, while hundreds of non-opiate drugs so tested had no significant affinity for it.

Dr. Snyder's studies on binding to the opiate receptor will help settle a basic pharmocological debate: Are drugs differentially potent because they bind to receptor sites to varying degrees, or because they perform differently once they bind to a site?

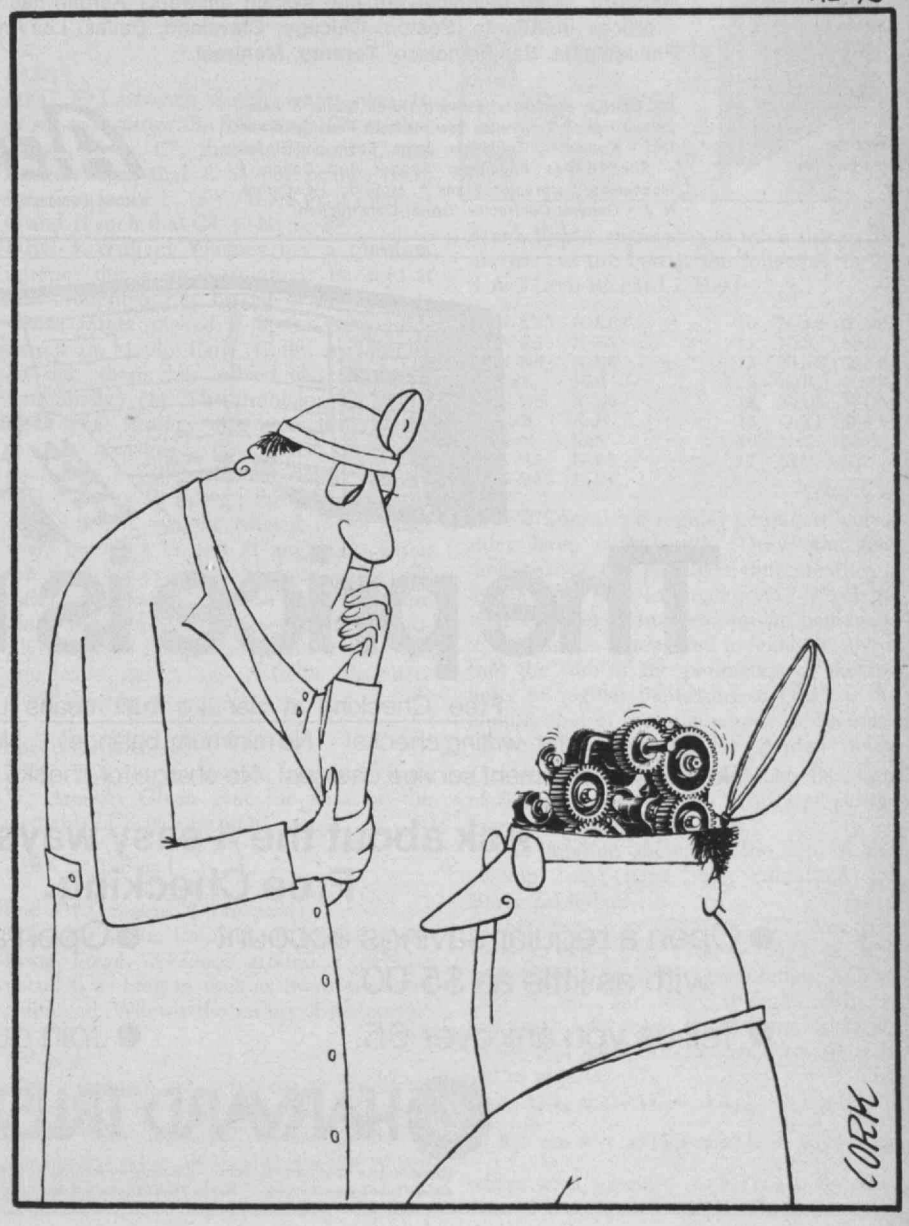
To Dr. Snyder the answer is clearly the former, at least in the case of opiates. The potency of each opiate he tested was directly related to how well it bound to the receptor. Also, according to his calculations, a drug evoked half the maximum response when half the receptor sites in an animal's brain were filled. Once on a receptor "a drug does its work and that's that," said Dr. Snyder. "There is no need to assume any intrinsic activity of a drug to explain its potency."

A clue to how opiates function was found in the distribution of opiate receptors in the brains of laboratory rats. High concentrations of receptors were found in regions of the brain known to be responsible for controlling such feelings as rage, and in areas in which pain is "felt." Seeking the receptor in parts of the body other than the brain was relatively fruitless.

The opiate receptor is a basic feature of vertebrate life. Dr. Snyder and his colleagues found it in fish, toads, chickens and monkeys. This fact raises a strong likelihood, partially confirmed by other scientists, that there is an intrinsic opiate-like substance in the body that performs some needed function and that acts naturally on the opiate receptor. Are we all opiate consumers in a sense?

Dr. Snyder also discovered a "sodium affect" that explains why narcotic antagonists—opiates that inhibit narcotic action—are generally far more potent than narcotic agonists—opiates that produce a "high" and kill pain. Previously researchers were puzzled by this difference in potency because there was little difference in how well the two classes bound to the opiate receptors in test tubes. Dr. Snyder and his colleagues discovered that "natural concentrations of sodium weakened the binding of agonists, while strengthening the binding of antagonists."—*D.M.*

MAYBE NOT AN UNDERSTANDING OF THE BRAIN, BUT A WORKING KNOWLEDGE? Such advances as Dr. Solomon H. Snyder's discovery of the opiate receptor in the brain may allow intelligent engineering of drugs, even though the complexities of the brain may remain elusive.



Crossing a 1,000-Mile Desert In a 10-m.p.g. Car

Puzzle Corner
by
Allan J. Gottlieb

Hello again.

During a weak moment, your editor has been convinced to play rugby. When I was at M.I.T. our intramural football games were often played adjacent to the rugby field. Whenever our ball strayed onto their field, we would wait until the "maniacs" went to the other end of their field before retrieving our ball. Surprisingly enough, I was only moderately hurt (bruised ribs) during our first game, and after missing game two I am ready for the third game next week. This may explain any columns for the remainder of this year which seem disjointed.

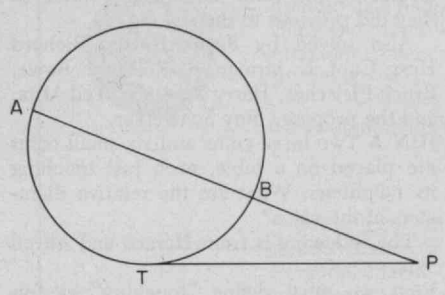
Problems

DEC 1 We start this month with a bridge problem from Michael Kay. With the following hands, South has a seven-hearts-doubled contract and West leads the ♠9. Can South make his contract?

	♠ A Q 10 7 ♥ 9 7 6 5 4 3 ♦ 2 ♣ Q 7	
♠ 9 8 5 4 ♥ J ♦ K Q 4 3 ♣ K J 9 8		♠ K J 6 3 ♥ 10 ♦ 9 7 6 5 ♣ 5 4 3 2
	♠ 2 ♥ A K Q 8 2 ♦ A J 10 8 ♣ A 10 6	

DEC 2 In January, 1974, Donald E. Savage sent us the following published as a "speed" problem: "Each of N dogs located at the N vertices of a regular N-gon simultaneously sees the dog at the next clockwise vertex and runs toward him. All the dogs run at exactly the same speed and thus finally meet in the center of the polygon; how far will each dog travel?" Now Mr. Savage is back with a similar, but harder, problem: Four hovering hummingbirds are equidistant from each other when the first sees the second, the second sees the third, the third sees the fourth, and the fourth sees the first. Simultaneously each begins flying toward the one it sees, always pointing directly at it; they all fly at the same speed. How far will each travel before there is a collision?

DEC 3 The following geometry problem is from Joseph Horton: In the diagram, PT is tangent to the circle and we are given that AB = PT. Prove that $(AP)(BP) = (AB)^2$.



DEC 4 Lawrence Smith wants you to prove or disprove the following: Given that $A^2 + B^2 = C^2$, that A, B, and C are integers, and that C is not prime; then, for some factor F, of C, there exist integers G and H such that $G^2 + H^2 = F^2$.

DEC 5 William Wagner has a question apropos our energy situation; he says it was brought to him by one of his students whose father picked it up at Xerox Research in Menlo Park, Calif. Apparently no one there has solved it completely (minimally) yet. The problem: To determine what strategy minimizes the amount of gas consumed (= miles travelled) traversing a 1,000-mile flat desert by car. The car gets 10 m.p.g.; the tank holds 25 gal., and gas may be carried in no other way; gas may be left at any point along the way (essentially, the tank holds 250 *miles*, and miles may be left anywhere along the way); there is an unlimited supply of gas at mile 0; but, except for what you leave, gas is not available anywhere along the way.

Speed Department

DEC SD 1 A matrix quickly from W. Arendt: Given that the sum of the elements of X is 1 and that

$$X^tBX = 3;\ B = \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix},$$

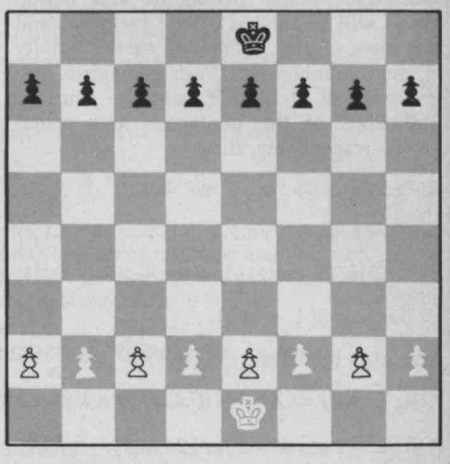
find X (X^t means X transpose).

DEC SD 2 The following is from R. Robinson Rowe: A fence around a circular corral is as long in rods as there are acres contained. What is the radius of the corral?

Solutions

The following are solutions to problems published in the June issue.

JUN 1 What is the minimum number of moves needed to reach the position shown at the top of the next column:



Ted Mita, Eric Jamin, and the proposer, Frank Rubin, were able to solve this in 18 moves, but the best is the following in 17 moves from Richard I. Hess:

1	N-KB3	N-KB3	10	N-N6	N-N6
2	N-K5	N-K5	11	NxR	NxR
3	N-N6	N-N6	12	N-N6	N-N6
4	NxR	NxR	13	NxB	NxB
5	N-N6	N-N6	14	N-Q6	N-Q6
6	NxB	NxB	15	Q-K1	Q-K1
7	KxN	KxN	16	NxQ	NxQ
8	N-R3	N-R3	17	KxN	KxN
9	N-B4	N-B4			

JUN 2 Consider a regular pentagon whose sides have unit length. Draw the five diagonals of the pentagon thus creating a five-pointed star (a pentagram) which in turn encloses a smaller regular pentagon. If this process is repeated indefinitely, show that the sum of the perimeters of the infinity of regular pentagons so created, including that of the original one, is 5ϕ units where ϕ is the so-called golden mean $[= \frac{1}{2}(1 + \sqrt{5})]$ and that the sum of the perimeters of the infinity of pentagrams so created is ten units.

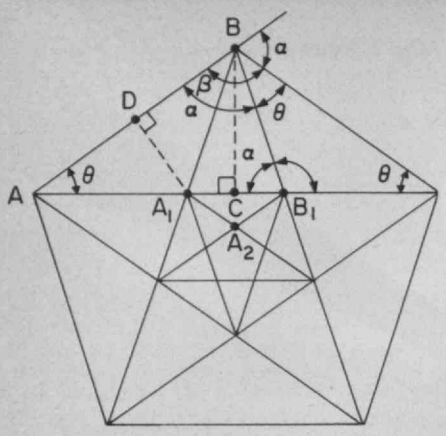
The solution shown at the top of the column, next page, was submitted by Harry Zaremba:

In the figure, $\alpha = 360°/5 = 72°$, $\beta = 180 - \alpha = 108°$, $\theta = (180 - \beta)/2 = 36°$, and AB = a = 1. By construction, AD = DB = a/2, and since triangle ABB_1 is isosceles, $AB_1 = a = 1$. From triangles ADA_1 and ABC, $AA_1 = a/(2 \cos \theta)$, and $AC = a \cos \theta$.

Also, $A_1B_1 = 2(AC - AA_1)$

$$= 2[a \cos \theta - a/(2 \cos \theta)] = aw, \quad (1)$$

where $w = (2 \cos^2\theta - 1)/\cos \theta$. By relation (1), $A_1B_1 = w \cdot AB$. Thus, any two



successive similar pentagons and pentagrams will be related by the factor w, and the sums of the perimeters of the infinity of their number will form geometric progressions. If P_1 and P_2 are the sums of perimeters of the pentagons and pentagrams, respectively, then:

$$P_1 = 5a(1 + w + w^2 + \ldots)$$

$$= 5a/(1 - w), \text{ and} \qquad (2)$$

$$P_2 = 10a/(2\cos\theta)(1 + w + w^2 + \ldots)$$

$$= 5a/[\cos\theta(1 - w)]. \qquad (3)$$

Also from the figure,

$$A_1B_1 = AB_1 - AA_1 = a - a/(2\cos\theta), \text{ or}$$

$$A_1B_1 = (2\cos\theta - 1)a/(2\cos\theta). \qquad (4)$$

Equating (4) and (2) and solving for $\cos\theta$, $\cos\theta = (1 + \sqrt{5})/4$. Hence, $w = (\sqrt{5} - 1)/(\sqrt{5} + 1)$, which when substituted with $\cos\theta$ into (2) and (3) gives
$P_1 = 5(\sqrt{5} + 1)/2 = 5\phi$, and
$P_2 = 10$ $(a = 1)$.

Also solved by Richard Hess, Eric Jamin, John E. Prussing, R. Robinson Rowe, Frank Rubin, Joseph Haubrich, and the proposer, William Thompson.

JUN 3 Enter in the open squares all the missing numbers from 1 to 256 (no duplications), so that the total of all the numbers in each horizontal row, the total of all the numbers in each vertical row, and the total of the numbers in each of the two diagonal rows (corner to corner) will equal 2,056 in each of the three categories.

The solution shown at the right is from Mrs. Leonard Fenocketti; the numbers in grey are those originally given, those in black are Mrs. Fenocketti's:

Also solved by Richard Hess, Frank Rubin, Eric Jamin, Dick Boyd, Harry Zaremba, William Wong, and the proposer, Mark Yellon.

JUN 4 A man is sitting in a wooden rowboat in his swimming pool. Both the pool and the boat have gauges on them to measure the water level. How does each gauge reading change as the water level changes, when:

1. The man sits in the boat?
2. The man loads the boat with bricks?
3. The man drops all the bricks overboard into the pool?
4. The boat develops a fast leak and swamps?

This is similar to a "basic smartness test" which I was unofficially given while an employee of Grumman Aircraft. I don't remember how I did, but I was rehired for eight summers. Joseph Haubrich would surely qualify; here is his solution:

When the man sits in the boat, it displaces more water and thus both gauges go up. The same thing happens when the man loads the boat with bricks, assuming the boat will hold the bricks. When the man dumps the bricks overboard, the boat, freed of the weight, moves up, so its water gauge shows falling water; the bricks sink, and the water in the pool lowers because the bricks do not displace their full weight any more. As the boat sinks, the gauge on the boat shows water rising; the gauge on the pool shows no change, because people and wooden boats are still slightly buoyant, displacing the same amount of water as they did previous to the sinking.

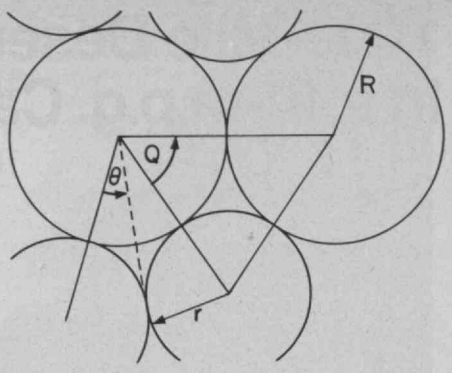
Also solved by Frank Rubin, Richard Hess, Capt. E. Jarman, R. Robinson Rowe, Bruce Fleischer, Harry Zaremba, Ted Mita, and the proposer, Roy Schweiker.

JUN 5 Two large coins and six small coins are placed on a table, each just touching its neighbors. What are the relative diameters of the coins?

The following is from Horace and Alfred Sklar:

First we must define "touching" as follows: two touching circles have a common tangent and hence the line joining their centers goes through the point of contact. Defining θ and φ as in the drawing at the top of the next column, we have:

1. $\cos\varphi = R/(R + r) = 1/(1 + \alpha)$;
$\alpha = r/R$, $0 < \varphi < 90°$
2. $\sin\theta = r/(R + r) = \alpha/(1 + \alpha)$;
$0 < \theta < 45°$



These two equations have three unknowns. The third equation is obtained by counting all the angles:

3. $10\theta - 2\varphi = 2\pi$

Solving:

$\cos\varphi + \sin\theta = 1$
$\sin\theta + \cos(\pi - 5\theta) = 1$
$\sin\theta - \cos 5\theta = 1$, $0 < \theta < 45°$

A numerical solution using the Newton approach is now done:

$\theta_{k+1} = \theta_k - f(\theta)/f'(\theta)$
$f'(\theta) = \cos\theta + 5\sin 5\theta$
$f(\theta) = \sin\theta - \cos 5\theta - 1$
$\theta_{k+1} = \theta_k - (\sin\theta - \cos 5\theta - 1)/(\cos\theta + 5\sin 5\theta)$
Let $\theta_0 = 25° = .436\text{---}$ rad.
$\theta_1 = \theta_0 - f(.436\text{---})/f'(.436\text{---})$
$= \theta + .00076$
$\theta_1 = .437093059$
$\theta_2 = .437093916$ (error is less than 10^{-10})
$\theta_2 = 25.04363665°$
$.423308386 = \alpha/(1 + \alpha)$

256	243	242	253	48	35	34	45	32	19	18	29	208	195	194	205
245	250	251	248	37	42	43	40	21	26	27	24	197	202	203	200
249	246	247	252	41	38	39	44	25	22	23	28	201	198	199	204
244	255	254	241	36	47	46	33	20	31	30	17	196	207	206	193
80	67	66	77	160	147	146	157	176	163	162	173	128	115	114	125
69	74	75	72	149	154	155	152	165	170	171	168	117	122	123	120
73	70	71	76	153	150	151	156	169	166	167	172	121	118	119	124
68	79	78	65	148	159	158	145	164	175	174	161	116	127	126	113
144	131	130	141	96	83	82	93	112	99	98	109	192	179	178	189
133	138	139	136	85	90	91	88	101	106	107	104	181	186	187	184
137	134	135	140	89	86	87	92	105	102	103	108	185	182	183	188
132	143	142	129	84	95	94	81	100	111	110	97	180	191	190	177
64	51	50	61	240	227	226	237	224	211	210	221	16	3	2	13
53	58	59	56	229	234	235	232	213	218	219	216	5	10	11	8
57	54	55	60	233	230	231	236	217	214	215	220	9	6	7	12
52	63	62	49	228	239	238	225	212	223	222	209	4	15	14	1

$\alpha = .73402903 = r/R$
$R/r = 1.362343939.$

Also solved by John E. Prussing, Winthrop Leeds, Carl Muckenhoupt, Winslow Hartford, R. Murphy, Meredith Schoppee, R. Robinson Rowe, Richard Hess, Joseph Haubrich, Harry Zaremba, James Friend, John Bobbitt, Ken Kivenko, Ralph Runels, Jeffrey L. Kenton, Eric Jamin, J. J. Williams, Arthur W. Anderson, and Ruth Fox.

M/A 4 (as revised in June) The God of Truth and the God of Falsehood are obvious; then there is also the God of Malice, who gives random answers to any question. You are to ask three questions and determine from the answers who is who.

The following is a slightly modified version of a solution submitted by Homer Schaaf; the idea of this solution is to use the first question to find one god who is *not* the God of Malice. Initially there are six possibilities:

	G^1	G^2	G^3
1	T	M	F
2	T	F	M
3	M	T	F
4	M	F	T
5	F	T	M
6	F	M	T

Let the first question be addressed to G^1: "The God of Truth and the God of Falsehood are opposites; the God of Malice is not the opposite of any god. If I asked you if G^2 were your opposite, would you say yes?" An answer of "yes" eliminates permutations 1 and 6 (so that G^2 is not the God of Malice), and an answer of "no" eliminates 2 and 5 (G^3 is not the God of Malice). Now ask the god known *not* to be Malice if 1 plus 1 is 2; if he says "yes" he is Truth, and if he says "no" he is Falsehood. You know, then, whether or not to believe him when you ask him who is the remaining God.

Responses were also received from John Joseph, R. Robinson Rowe, Eric Jamin, Ted Mita, Neil Hopkins, and Carl Faflick.

Better Late Than Never

PERM 1 As mentioned previously, only solutions without the greatest integer function will be printed. I have also omitted solutions using a decimal point. Recall that $x^{1/2} = \sqrt{x}$ is legal. This month's contributions come from Greg Girolami, Eric Jamin, Alfred Aburto, Harry Zaremba, Frank Rubin, Woodrow Johnson, and an anonymous doctor from Bridgeport, Conn. This month I present solutions from 257 to 300—a series in which there are still many gaps. For 1 to 256, see several issues in last year's volume. Solutions to numbers omitted from the following have already been printed.

$257 = 3!!/\sqrt{9} + 17$
$258 = \sqrt{9}!(7(3!) + 1)$
$259 = 37(1 + \sqrt{9}!)$
$260 =$
$261 =$
$262 = 7[\sqrt{9}! + (3! - 1)!]$
$263 =$
$264 =$
$265 =$
$266 = 3(91) - 7$
$267 =$
$268 =$
$269 =$

$270 = 9^{1/3}3!!/(7 + 1)$
$271 =$
$272 = 7(39) - 1$
$273 = 7(39)1$
$274 = 7(39) + 1$
$275 =$
$276 = 17(9) - 3$
$277 =$
$278 =$
$279 = 9[7 + (3 + 1)!]$
$280 = 91(3) + 7$
$281 = 7!/(3!9^{1/2}) + 1$
$282 =$
$283 = (3! - 1)! + 7(9)$
$284 =$
$285 =$
$287 = (9^{1/2!})^3 + 71$
$288 = (97 - 1)3$
$289 = 17^{(3!/9^{1/2})}$
$293 =$
$294 = (97 + 1)3$
$295 =$
$296 =$
$297 =$
$298 =$
$299 =$
$300 =$

One correction has been received:
$108 = 9(7 + 3! - 1)$

M/A 3 Comments were received from George Cain and R. Robinson Rowe.

M/A 5 Winthrop Leeds prefers the following solution, since it uses common words:

P R A M
L E V Y
U N I T
G O S H

MAY 2 Another proof was submitted, this one from A. C. Williams.

Proposers' Solutions to Speed Problems

DEC SD 1 $\left[\frac{1}{3}\ \frac{2}{3}\right]$

DEC SD 2 Each rod of fence bounds a one-acre sector, with an area of ½R. Since 160 square rods equal an acre, the radius must be 320 rods, which is just one mile.

Allan J. Gottlieb studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973), and he is now Assistant Professor of Mathematics at York College of the City University of New York. Send problems, solutions, and comments to him at the Department of Mathematics, York College, 150-14 Jamaica Ave., Jamaica, N.Y., 11432.

Books

Management Is Not Enough

Management: Tasks—Responsibilities—Practices
Peter F. Drucker
New York: Harper and Row, 1974; 839 pp., $15.00

Reviewed by Leopold R. Michel and Richard B. Maffei

At the outset of this immensely comprehensive, pro-management work, Peter Drucker announces that "performing, responsible management is the alternative to tyranny and our only protection against it. . . . If our institutions do not perform in responsible autonomy, we will not have individualism and a society in which there is a chance for people to fulfill themselves."

Can we advance toward happier fulfillment simply by emerging from the "management boom" (the decades of the 1950s and 1960s) and pursuing now a straight path toward "management performance" through better knowledge of the tasks and required skills of the managers? This appears to be the central thrust of this book, and through it all there remains the unannounced but profusely illustrated implicit need to be moral and virtuous. To be sure, Mr. Drucker sidles away from any blatant statement, hewing closely to that pragmatic position that has always made his work directly appealing to businessmen and less acceptable to some scholars in the field. But he has clearly moved to weld ethics to practice in ways that are acceptable to practitioners of business in industrial institutions.

However, there remains the need to defend efficient practices and performance by management with a well defended philosophical posture. Drucker does not do this. Perhaps he regards it a non-problem; but to these reviewers it is the heart of the problem. Tyranny in the past has been made possible by excellence in management and planning; tyrants have been able to manage their uprisings. Externalities neglected by yesterday's and today's managers now cause national and international concern; in even the least productive bureaucracies there is much traditional "management." In his emphasis on people and planning, Drucker neglects both entity goals and aggregate system goals. But especially after the nation's moral trauma of Mr. Nixon's second term, we clearly need a statement of management philosophy which focuses on the moral and human issues—the need to provide every individual on spaceship earth with a viable and aesthetic set of economic purposes, and to provide each institution with a larger sense of values and purpose than can be measured by efficiency, income, and profit. Legitimacy and quality of life deserve deeper and extended interest.

There are guidelines in bodies of thought outside the field of management which need to be known and shown: cultural and philosophical anthropology, selected fragments of theology, and legal theory.

Though this book is a milestone on the way toward a richer definition of freedom and responsibility through viable organized practice, it is also pragmatic and question-begging. "We are moving from management boom to management performance," writes Mr. Drucker, proposing what he calls the leitmotiv of this book. A new opus—grand and enjoyable. But we are now seeking a differently orchestrated leitmotiv.

Richard B. Maffei is Associate Dean—Academic Affairs of the School of Management at Boston College. Leopold R. Michel, a management consultant, was Visiting Lecturer in the Boston College School of Management before his retirement one year ago. Both have studied at M.I.T., Dr. Maffei in the Sloan School of Management (where, he has been a member of the faculty) and Mr. Michel in the Department of Mechanical Engineering.

Inflation: No Simple Cure for Subtle Causes

The Earnings Conflict
Wilfred Brown
New York: John Wiley and Sons, 1973; 126 pp.

Reviewed by Daniel Quinn Mills

The problems of wage and price inflation continue to bedevil the British even more than they do the U.S. Wilfred Brown, an industrialist and writer on management topics, has proposed in *The Earnings Conflict* a plan to resolve the inflation problem in Britain. Brown has some 25 years of experience as managing director and chairman of a British manufacturing corporation and has held influential government posts in recent years, so his ideas deserve to be taken seriously.

Brown perceives inflation in the British economy as an economic problem with

primarily social and political causes. His view is that inflation is due to trade union power, either exclusively or in the sense that other sources of inflation are now controllable by the government, while union-created wage-push inflation is not. This is an assessment that commands the support of other influential British commentators, including, for example, the editors of *The Economist* and Aubrey Jones, former Chairman of the Prices and Incomes Board (see his *The New Inflation: The Politics of Prices and Incomes*, London: Deutsch, 1973).

Given this view of the sources of inflation, the essence of the search for a solution is to find a method of controlling the unions. But over the last two decades the British have assembled an impressive array of governmental failures to do just that. Among the most recent are Mr. Jones' Prices and Incomes Board (a form of so-called "incomes policy") and the Industrial Relations Act of 1971. The Act, modeled largely after American labor legislation, was intended to transport to Britain the type of public control of union behavior that exists in the United States (though it may surprise many Americans to think of our system in this way); it was largely unsuccessful and was repealed by the new Labor Government on August 1, 1974.

A Coercive Regulatory Plan

Brown has another proposal for controlling the unions. He proposes the establishment of a National Council for the Regulation of Differential Wages (N.C.R.D.), to be composed exclusively of trade union officials (up to 300) who would receive full-time salaries from the government. There are to be no employers' representatives on the Council.

According to Brown's outline, the N.C.R.D. would have a major role in formulating British national economic policy. Each year, following Parlimentary debate, the government would announce the percentage amount which could be added to the national wage bill for the following year. The N.C.R.D. would then make recommendations to the government about differential percentage increases to be paid workers in various employment groups, the total of these differential increases to correspond to the overall percentage limit established by the government. Each employer would then be required to raise the wages of workers according to the legal schedule for the occupational group concerned. The threat to withhold all sources of income or government support from strikers would secure the nation from labor stoppages.

Internal procedures for the N.C.R.D are fully detailed. Its recommendations are to be adopted by *unanimous* vote only. If at the end of a year the N.C.R.D. remained in disagreement on its recommendations, wages would remain frozen. N.C.R.D. debates would be "in the full glare of publicity."

In a moment of candor, Brown asks, "Will it work?" He admits that "the answer cannot be certain. It is a matter of risk-taking."

The two most important insights of the proposal—they are not original with Brown—are:

—A nationwide percentage guideline for wage adjustments must somehow be divided unequally among firms and occupations because of economic and social factors.

—Union must somehow be involved in this process in a way which obtains their support for the results.

Brown is clearly wrong in suggesting that employers be excluded from the process of adjusting differential wages, and he clearly is too optimistic about the potentialities of the particular organizational framework he proposes.

The True Sources of American Inflation

It is probably presumptuous for an American reader to comment critically on a proposal for incomes policy in Britain. But what may we say about the relevance of such proposals to American conditions?

First, it is likely that we will see many similar proposals in the next two or three years. The United States is now emerging from an inflation originating in commodity markets (agricultural products, energy, and raw materials) and is entering one in which wage adjustments, interest rates, and the attempt by firms to widen profit margins will play the primary inflationary role. As this transition becomes more broadly perceived, public discussion will focus more strongly on the economic power of unions, financial interests, and big business. Furthermore, it may be expected that each of these will blame the others for its own behavior. Out of the resulting political arguments about the economy will come various proposals for increasing governmental regulation of economic institutions in our society—regulation of the type now so common in Britain. Perhaps some additional regulation may even be found appropriate within our economy, although the recent period of wage and price controls has demonstrated certain limitations of the regulatory approach.

Toward Structural Economic Reform

What may be said about the inflation problem in the United States? At the outset, it remains important that we pursue fiscal and monetary policies which are consistent with economic stability. Yet it should be clear from the experience of 1973 and 1974 that restrictive fiscal and monetary policies are not alone sufficient to generate price stability without undue economic dislocations. Thus we confront a situation in which both traditional tools of economic stabilization policy—fiscal and monetary policies and direct wage and price controls—seem to be of limited usefulness in the effort to restrain inflation.

It is time to recognize that inflationary pressures which originate from changes in our economic circumstances (such as materials or fuel shortages or crop failures) affect the total economy through particular markets, and that the institutional arrangements of these markets have much to do with the inflationary impact of the initiating events. There is an important role for the federal government in responding to events which may have foreseeable inflationary consequences and in modifying those aspects of the structure of the economy that may exacerbate inflationary pressures. Indeed, the need for structural reforms has lately been receiving increasing attention. For example, Hendrik S. Houthakker (formerly a member of the President's Council of Economic Advisors) has suggested (see the *Wall Street Journal*, July 30, 1974) major realignments of public policy for such sectors of the economy as agriculture, transportation, and energy where the result of current government regulation is to add to costs and raise prices. And John T. Dunlop (formerly Director of the Cost of Living Council) has suggested several ways in which government leadership and initiatives to resolve bottlenecks and generate improved collective bargaining would be of value in industries in which the structure of markets and behavior of unions and business firms contribute to inflation (see his speech to the Society of American Business Writers of May 6, 1974, published in the *Sloan Management Review*, Fall 1974).

The list of structural reforms that need to be made is long, and the current failure to do anything simply prolongs the problems we face. It is an illusion, although a very tempting one, to seek to resolve inflationary pressures primarily by direct regulation of prices and wages and increasing coercion applied to the economic behavior of firms and unions. To the extent that American commentators and politicians engage primarily in this largely futile political exercise, thus following the British example, we shall squander our energy and our opportunities to restrain the inflationary behavior of our economy.

D. Quinn Mills is Associate Professor of Industrial Relations in the Sloan School of Management, M.I.T. He was formerly Special Assistant to the Director of the Cost of Living Council and Chairman of the Construction Industry Stabilization Committee.

Changing Cornerstones of Modern Science

Physics Fifty Years Later
Sanborn C. Brown, Editor
Washington, D. C.: National Academy of Sciences, 1973; vii + 406 pp., $11.00

Reviewed by Herman Feshbach

Surely almost everyone is aware of the enormous increase in the understanding and control of nature achieved by man—and of the fact that a major fraction of these advances took place within the last 50 years, the period celebrated by the volume under review. Revolutions have occurred in our means of transport and storage, in our methods of communication, and in our procedures for storing and retrieving information; new materials have been created; a whole new arsenal of drugs is available for the prevention and treatment of disease; agriculture has achieved new heights of productivity, an enormous variety and quantity of foods are available; a new source of energy has been discovered; and the direct exploration of space has begun.

It is perhaps less universally realized that during these same 50 years, there have been discoveries every bit as revolutionary for the physical and biological sciences as sciences. Some of these have already had a major impact on everyday life, and it is already clear that others will be as important in the near future. Indeed, this is an age which is characterized by the speed with which scientific advances are exploited for industrial ends and human needs.

Processes, Forms, and Concepts of Matter

These scientific discoveries of the last half-century are of three sorts:

—*New objects and new processes* in our universe are observed with new devices of improved sensitivity and accuracy. Examples are the discovery of such new types of stars as quasars and pulsars, of various varieties of molecules in interstellar space, and of the existence of the continental drift.

—*New forms of matter* have become known through studies of ever-increasing physical sophistication. Fifty years ago only one type of matter was known—aggregates of molecules which under various external conditions of temperature and pressure are solid, liquid, or gaseous. Now several additional types of matter have been identified. One is a neutral aggregate of positive ions and electrons called the plasma. Another is nuclear, the stuff of which nuclei are made. Now we have confirmed the existence of various families of particles such as pions, kaons, and hyperons, and within the last decade we have begun to probe the proton and the neutron to determine the role of such exotic constituents as "quarks" or "partons."

Each of these forms of matter can exist in different states. Nuclear matter in atomic nuclei is in a "liquid" state, but in a neutron star such matter is thought to take on a lattice-like structure similar to that of a crystal.

Each type of matter has its equation of state, each its characteristic modes of motion. These properties are not clearly understood for these new types of matter, and even in the case of "common, everyday" matter they are not yet fully exploited. So research continues with a wide variety of experimental tools ranging from accelerators to lasers. Under suitable conditions even familiar atoms and molecules have remarkable and often useful properties; consider, for example, materials such as semi-conductors, such phenomena as superfluidity and superconductivity, and such successful exploitations of molecular properties as the laser.

—*A fundamental conceptual framework* in which the phenomena belonging to the first two categories described above are to be understood. Classical physics rests upon such cornerstones as the Newton equations of motion suitably modified to include relativistic effects, the Maxwell equation describing the electromagnetic field, and the laws governing aggregates of matter as contained in classical statistical mechanics and thermodynamics. The discovery of quantum mechanics, generally considered to be one of the great intellectual accomplishments of man, occurred near the beginning of the 50-year period. Originally invoked to explain the properties of atoms, quantum theory is now found universally applicable to all physical phenomena. The properties of molecules—and in principle, therefore, all chemical phenomena—can be understood using quantum mechanics as a framework. Quantum mechanics has been found to be appropriate for the discussion of nuclei and, combined with relativity, has provided an incredibly accurate description of the properties of the electromagnetic field. Indeed, no physical phenomenon has to this date appeared which does not obey the laws of quantum mechanics.

Recently one possible new conceptual framework has been suggested; it proposes a unification of the electromagnetic field and the weak interactions which are responsible, for example, for the beta decay of nuclei, and if it proves to be correct another far-reaching advance will have been made.

Knowledge as a Source of Power

Most of these matters are described in the essays in this book. The authors are leaders in their fields, and their essays are at once both clear and accurate; they should prove accessible and of interest to a wide audience.

It is easy for scientists who have been and are part of this great enterprise—the understanding of nature—to be proud of the accomplishments of these 50 years. Let them also remember that the knowledge acquired by these scientific explorations, no matter how innocent, is a source of power. It is the duty of all of us to be sure as best we may that this power is used to create a peaceful world in which each life can be productive and satisfying.

Herman Feshbach is Head of the Department of Physics at M.I.T.

Praising Old Virtues in Engineering Design

Theory of Design
Peter C. Gasson
New York: Harper and Row Publishers, Inc., 1973, 230 pp.

Reviewed by David Gordon Wilson

The discipline of engineering design lies somewhere between the apparent anarchy of modern painting and the scientific precision of predicting the paths of bodies in space. As for most present-day painting, there are no rules in engineering design by which to judge its rightness or wrongness except the fundamental criterion, "Do I like it?" Thus the essential quality of design is separated from the controlling necessity of fulfilling certain objectives.

The fulfillment of certain objectives can be translated as, "It has to work," and Peter Gasson's book is rich in material to help a student determine the engineering viability of a design; it is mostly about certainty rather than about uncertainty, about "hard" areas such as stress analysis and materials and reliability.

There is an interesting section on the "softer" area of aesthetics in which the author gives some broad rules—surely arguable ones—for proportions that will give objects acceptable shapes. Ten lines deal with environmental hazards, mainly those of travellers in automobiles.

This cursory treatment of the environment illustrates the principal problem faced by authors of design textbooks. Even if one limits "design" somewhat to "mechanical-engineering design," one must still grapple with a vast range of knowledge. To attempt even a small part of this range in a moderate-size text is to invite criticisms of superficiality and dilettantism. I found myself looking up one of the few areas about which I think I know something and inevitably concluding, in what has to be professional jealousy, that students would be more misled than helped.

The task of the design-text author and the design teacher becomes more difficult every year. Only two decades ago we didn't have to worry about fluidics and integrated circuits and filament winding because they didn't exist. We could concentrate nicely on gears and clutches and camshafts. Today, however, a cornucopia of phenomena, techniques, processes and gadgets may be used in designs; and so, we at M.I.T. teach design almost entirely by the case or project method. We recognize that the case method gives students an exposure to only a small fraction of the many alternatives with which a designer can work, but we hope that they gain enough confidence to tackle design problems and, on the basis of an ever-growing experience, utilize on their own an increasing range of the techniques and processes that are available.

We also spend much more time on the areas of uncertainty—and of design freedom—than does this text. We try to show that a good designer cannot proceed by cold logic to a unique ultimate goal. Many alternative solutions to problems can normally be developed. Out of these alternatives (all fulfilling the specifications) he must choose one or more as "right."

All Things Great and Small

The creator was the perfect designer, having created heaven, earth, plants and trees, and every creature that moves upon and over and under the earth. What a variety of ways was chosen to fulfill the need for movement! Which was the best choice? Where would you place the turtle, the salmon, the dolphin, the kingfisher? The beaver, the cat, and the mudwasp? When one looks at any of these creatures as a design system not only for moving but also for finding food, reproducing, making a home, and warding off enemies, one has to conclude that each is as near perfection as mere humans can imagine.

Engineering diversity cannot be as great as nature's, particularly when the performance specifications are more exact than the simple requirement of movement. But the diversity of engineering is large. Consider, for example, the two leading internal-combustion aircraft-engine types which emerged from the first World War: the air-cooled radial and the water-cooled in-line vee. At the start of World War II these two types, developed to much greater power and efficiency, were still

rivals; vigorous advocates were still debating their acknowledged and disputed advantages. We might be arguing over them still if the jet engine had not come along to render the arguments academic.

As specifications are made more and more difficult to attain, the diversity of design alternatives diminishes. There may be 1,000 distinct, feasible ways to open a tin can, but the number of alternative types of man-landers for Venus is presumably small. As the emission control standards for automobile engines were progressively tightened, the number of different engine types put forward for consideration at first increased greatly. But as testing proceeded, it became clear that many of these engines would no longer be feasible.

The Use and Misuse of Creativity

The message is that designers must not be stifled by such cries as, "It's a lousy idea and it won't work." If the second clause of this statement can be shown to be true, then the first must necessarily follow. Even in a lawless age, Newton's laws of motion would be inviolate. Above all, a design has to work. We have all known beautiful (and ugly) can openers which just don't work, and those can be dismissed. Then those that do work can be judged on a variety of criteria such as convenience, life-cycle cost, reliability, and so on. Or, on a more sophisticated level, all the criteria can be related to one another by means of trade-offs, and a single criterion of excellence can be obtained.

Fortunately for designers, either the trade-offs or the data on which they are based are usually highly disputable. For if a single criterion could be obtained to judge a design, the procedure could be reversed from analysis to synthesis and then a computer program could be devised to spew out perfect designs for any conditions. But at this point creative design would no longer exist. Uncertainty is an essential condition of the design process; it is only the true designers who enter unflinchingly to exercise their biases and inspired guesses in this arena of ambiguity.

But this book is about the theory of design, and it should not be faulted for leaving out what we consider to be the philosophy. Most current U.S. textbooks treat the theory of design somewhat differently. Authors can sometimes be criticized for over-reacting to environmental and human concerns, without sufficiently stressing excellence in the theory. Mr. Gasson's book avoids such pitfalls.

It has a strongly British character. When I was at a British engineering school in the late 1940s, economics and cost accounting were regarded as beneath the dignity of any mechanical engineer worthy of the name. It is reassuring to find that some old values remain, firm as a rock, in a world that seems to many of us to be going unstable because of the too-rapid change of everything familiar.

David Gordon Wilson, Professor of Mechanical Engineering at M.I.T., is an advocate of early exposure of undergraduates to the problems of engineering design; he is in charge of senior design subject and the systems and design division of the Mechanical Engineering Department.

An Institute Informant

The Editors' digest of recent and current concerns at the Massachusetts Institute of Technology

New Research Support

Grants for new research at M.I.T. announced at M.I.T. during the fall include:

—A comparison of **job training programs** managed by federal agencies and those set up by state and local agencies with federal "revenue-sharing" funds is to be made by the Industrial Relations Section of the Sloan School of Management. The $270,000 study for the Manpower Administration will continue for three years under the direction of Charles A. Myers, Sloan Fellows Professor of Management.

—Can **magnetized particles** be used for early diagnosis of asbestosis, some types of pneumonia, and perhaps other lung disease? A three-year $175,000 grant from the National Science Foundation to the Francis Bitter National Magnet Laboratory will continue magnetic detection studies—which so far have yielded a significant method for detecting interstitial lung disease due to magnetite dust inhalation.

—N.A.S.A. has confirmed a place on the joint U.S.-U.S.S.R. space mission next year for new experiments from M.I.T. on *crystal-growing* in the weightless environment of space. The new work will involve a detailed examination of the growth of germanium crystals; earlier experiments aboard Skylab III and IV showed that outer space offered striking advantages for growing homogeneous crystals. The work is under Professors Harry C. Gatos and August F. Witt, Center for Materials Science and Engineering.

—Research on the "**architecture machine**"—a study of computer-aided architectural design and of man-computer communications—will continue under a $600,000 grant of the National Science Foundation. Professor Nicholas P. Negroponte says the goal of the new three-year project will be "to design, build, and test a class of machines that can deal with the properties of incompleteness, contradiction, and vagueness—properties that are characteristic of any design behavior."

—M.I.T.'s continuing program in problems of **malnutrition in low-income countries** has received a $685,000 grant from the U.S. Agency for International Development.

—A long-range study of **newspaper distribution problems** which have traditionally plagued publishers is now underway in the Electronic Systems Laboratory and Sloan School of Management for the American Newspaper Publishers Association. It is the latest topic in a series under A.N.P.A. sponsorship at M.I.T.; earlier work has focused on computer applications in advertising management and layout.

A Cold, Dry Winter for Most of the East

As the fall days grow cooler, prognosticators both professional and amateur turn their attention to the winter ahead: Will it be long and cold, short and mild, or a little of both?

Amateurs may rely on such signs as the width of the brown bands on the "woolly-bear" caterpillars or on such second-derivative hearsay as a consensus of almanac editors. But Hurd C. Willett, Emeritus Professor Meteorology at M.I.T., who has devoted most of his scientific career to research on seasonal climatic variations, is convinced of their correlation—at least to some extent—with solar sunspot cycles. Over the years his studies have made possible climatic forecasts whose accuracy is hard to challenge.

What of 1974-75?

There is the possibility of a "very severe winter" this time, but the forecast has a "relatively low confidence rating."

Normal sunspot cycles suggested a year ago that 1974-75 should be warmer than normal. But "solar activity is departing strongly from the normal sequence of behavior," and Dr. Willett's research funds simply have not been adequate for the new, detailed analysis which the situation requires. Hence the following forecast prepared solely on the basis of a "distant solar analog with very limited climatic confirmation":

Temperature: A severely cold winter over much of the country, but relatively mild west of the Continental Divide. Most severe cold in north central and northeastern sections, where the winter may average more than 6°F. colder than normal. Coldest weather probably in January and early February.

Rain and snow: Precipitation will be generally deficient in the north central and far western sections, except heavy along much of the Pacific Coast; generally heavy from Texas and Oklahoma eastward to the South Atlantic Coast (south of Cape Hatteras); heavy also from the Eastern Great Lakes and the Ohio and Tennessee Valleys into the Appalachians; and relatively light in the immediate coastal sections north of the Virginia capes. Owing to the expected coldness, snowfall and particularly snow accumulation will be heavier than normal wherever precipitation is not substantially subnormal.

Energy: SCORE Starts a New ERA

Having designed automobiles and fought fires, Student Competitions on Relevant Engineering (SCORE) is ready for the ultimate challenge: "the design and construction of energy packages to meet the needs of homes, farms, and light industry."

SCORE was established in 1971 to sponsor collegiate engineering design and hardware-building competitions; over 3,200 students have participated in the Urban Vehicle Design Competition (1971-72) (*see "65 Cars in Search of the Future," October/November, 1972, pp. 43-54*) and Students Against Fires (1973-74) (*see "How Students Tackled America's Forgotten Problem," July/August, 1974, pp. 57-59*). In 1974-75 it will be Energy Resource Alternatives (ERA), and SCORE wants student teams from schools throughout the U.S. and Canada to work on energy packages—especially

on those which use nonconventional energy sources (wind, solar, synthetic gas, etc.)

The University of Wisconsin will be host to the 1974-75 competition, with final demonstrations in Madison early in August, 1975. Teams will share problems and solutions in a symposium on October 18, 19, and 20 at the University of Texas at Arlington, and there will be a second symposium early in the spring of 1975.

The emphasis is on original work. Commercial parts and systems may be incorporated in entries, and "innovative combinations and modifications of existing elements" are encouraged; but "no sponsor-supplied element of a proprietary nature will be permitted." And a "student innovation multiplier" will be applied to the scores of projects which demonstrate student-designed unconventional solutions.

For further information, write SCORE's Coordinating Committee at the College of Engineering, University of Wisconsin, Madison, 53705.

At Least 180 Computers Are at Home Here

Of all American universities, none has contributed more than M.I.T. to the development of modern computers. And none makes more intensive use of the product of this innovation.

There are at least 180 computers on the M.I.T. campus, and to operate them all costs nearly $9.5 million a year. That is 7 per cent of the Institute's general operating budget—not including Lincoln Laboratory; it is "a very large proportion," says Robert H. Scott, '64, Director of the Institute's Information Processing Services. It means that M.I.T. probably devotes a larger share of its annual operating budget to computers than any university in the world.

Of M.I.T.'s 180-plus computers (defined as "general-purpose programmable machines which can be made to serve many functions," a definition which rules out simple calculating machines and special-purpose devices perform a single operation for a single experiment), 12 are operated as computer facilities serving many different users for many different problems; to these machines is devoted $8.5 million of the annual computation bill.

Two of the 12 are large, general-purpose computers operated by the Information Processing Center to do by far the largest share of the M.I.T. community's computation—an I.B.M. 370/165 (some 5,500 users) and a Honeywell 61×80 Multics system (perhaps 1,300 users).

Mr. Scott thinks that at least 50 per cent of the professionals within the M.I.T. community—students, faculty, and staff—are using computers at any one time, and in the course of a year perhaps two-thirds of all such workers at the Institute use computers. In addition to access through their normal classroom and research work, at least 1,000 undergraduates use machines for their own projects through the Student Information Processing Board, a student-managed clearing house with a budget of computer time for allocation to undergraduates.

Northeast's Largest Computer Center

Half of the computer time used at M.I.T. is devoted to research—by faculty, graduate and undergraduate students, and staff. Administrative activities—the Office of the Comptroller, the Registrar's Office, the Alumni Records Office, and others served primarily by the Office of Administrative Information Systems—account for just over one-quarter of the total computer time.

The School of Engineering uses about half of the computer time assigned to research and academic work, the School of Science 27 per cent, the Sloan School of Management 10 per cent, and the Schools of Architecture and Planning and of Humanities and Social Science 6 percent each.

But the Sloan School of Management spends a larger percentage of its total academic budget on computing than any other school, the School of Science the smallest. This is because, thinks Mr. Scott, research in the life sciences simply doesn't require as much computation as work in other fields. And large, highly specialized off-campus computer facilities—notably at the National Center for Atmospheric Research, Los Alamos National Laboratory, and the National Accelerator Laboratory (Batavia, Ill.)—are used instead of M.I.T. facilities by many workers in meteorology, physics, and the earth and planetary sciences.

Some 15 per cent of M.I.T.'s computer time is devoted to work for other institutions—chiefly Harvard, but also Tufts, Brandeis, and other New England colleges, universities, and even industrial firms; work is done for the latter only if appropriate commercial facilities are unavailable or if the work is in cooperation with computer projects at M.I.T. Indeed, M.I.T. now does much of Harvard's computing under an agreement concluded between the two institutions three years ago.

All this means that M.I.T.'s Information Processing Center is the largest such organization in the Northeast. Only a few other universities—larger institutions with far more students and faculty—anywhere in the nation have more computer capacity.

"Eventually Almost Everyone"

What about the unit cost of computing? Lower every year than the year before, says Mr. Scott, because the technology improves and because there are more users every year to share the cost of machines that are not yet fully utilized. Both trends will continue into the foreseeable future, he thinks—and, except for inflation, so will the trend toward lower cost . . . at least until growing demand renders M.I.T.'s two big computers inadequate and there is need for expansion.

Software—the matter of organizing a problem so that a computer can work on it and instructing the computer about the tasks to perform and how to report its results—is the biggest challenge for the M.I.T. Information Processing Center, just as it is for computer service groups everywhere. Most research and academic users bringing work to the Center provide their own software, and some of it is "very sophisticated"; but some people come to computing with no experience at all, says Mr. Scott, and helping them work out programming problems is "the most important thing we do." Indeed, programming represents perhaps 25 per cent of all the work of the Information Processing Center staff.

But with this kind of help available, with technological developments making computers more and more useful, and with problems growing ever more complex, Mr. Scott thinks "eventually almost everyone" at M.I.T. will find himself using the computer. Two problems, the chief barriers to this era when every desk will have its terminal as it now has its telephone: better interface facilities, to make computers easier for the uninitiated to understand and to use; and new software packages so that programs devised for one purpose can easily be adapted for others.

"Kiki Singing in a Montparnasse Cafe," 1933, is one of 62 photographs by Brassai on view recently at an exhibition entitled "The Eye of Paris," in M.I.T.'s Hayden Gallery. The show takes its name from Henry Miller's description of Brassai, one of the dominant figures in European photography, and spans three decades of the Hungarian artist's work in his adopted city of Paris.

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Letters

Continued from page 4

for the liquid-metal-cooled faster breeder reactor (L.M.F.B.R.) demonstration plant gives some idea of possible licensing difficulties that the breeder technology may have to face.

Among the nine L.W.R.s that entered service in the U.S. during the year 1973, the cheapest cost $185/kw. and the most expensive $480/kw. (1973 dollars)—more than a doubling in price to produce exactly the same product—electricity—by the same means. Consequently, it is difficult today to believe any engineering projection of the cost of L.W.R.s over the next ten years. There may, as Mr. Driscoll argues, be no technical reason to believe that a L.M.F.B.R. will cost more than an L.W.R. The point is that "technical considerations" may not be the principal determinant of costs. Our view is that the cost of a commercial breeder reactor in the U.S. is today highly unpredictable because of what seems to us to be intensifying opposition to nuclear technology among some interests and the apparent continuing success of these individuals and groups in using the administrative/judicial licensing apparatus to establish their views.

This perspective on the economics of nuclear power sheds some light on the limitations of foreign nuclear cost experience. In the case of France, which recently built an L.M.F.B.R. demonstration plant (Phenix) for the surprisingly low cost of $140 million, an L.W.R. ordered today is expected to cost only $250/kw. (1974 dollars) against $500/kw. (1974 dollars) in the U.S. for the same machine. French reactors are being built in an *entirely* different institutional context, in the virtual absence of public opposition; this suggests to us that cost experience from France is just not pertinent to the U.S. This is why we did not discuss the economics of the French breeder program in our article. We recognize the importance of the French experience as a demonstration of the *technical feasibility of* breeder technology, and we fully agree with Mr. Driscoll on this point. But this point has never been in dispute and therefore we never questioned it in our article.

Salt: Saving Freedom or Timber?

"Salt on the Earth" (*May, pp. 6-7*) should be read by all who insist on ice-free roads. Is the insistence upon such roads the result of people in our society growing up without individual responsibility, with tax-supported schools and tax-supported reaction? Can we expect such people to put chains on their automobiles, take a shovel for the drifts, and develop the skill required to drive an automobile on ice?

James F. Jackson
Carlisle, Ind.

Hedgerows have a number of useful functions not the least of which is the production of merchantable timber. In England, we are told, the privately owned hedgerows provide one fifth of the merchantable timber produced on the island.

Charles H. Blake
Hillsborough, N. Car.

REPORT OF THE PRESIDENT AND THE CHANCELLOR

FOR THE ACADEMIC YEAR

1973–1974

MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

IN MEMORIAM

Vannevar Bush
1890–1974

He was a man of the widest ranging intellect and practical curiosity whose precise and probing style of thought and work served as a model and an inspiration for young scientists and engineers for more than half a century. He avoided the easy way and taught by his own example that real achievement is the product of thorough preparation, careful procedure and diligent labor combined with the willingness to cultivate bold visions. His humane and sensitive way with associates—especially his students—together with the strength of his intellect brought forth generations of scientists and engineers whose achievements have changed the world.

INTRODUCTION

The annual Report of the President and the Chancellor has, by our third year, become part of the measured pace of the year. It is that occasion on which we assess where we have come, take notice of the achievements of many throughout the Institute, assess our shortcomings and problems, and consider the trajectory of the Institute into the future. Our major perception of the past year at M.I.T. is of a quickening of pace—a focusing of energies, consolidation of efforts, and progress toward the achievement of reaffirmed long-term goals.

The last few years have been ones of uncertainty and deep searching, as every sector of our society has taken stock of the complexities and incongruities of the contemporary world, and reassessed its goals and its effectiveness. M.I.T., too, has been engaged in such an examination. We faced a society uncertain of its goals and seriously questioning the role of technology, a political mood less understanding and supportive of basic research than before, and a government policy designed to cut back graduate education in science and engineering. As a consequence, many young people were hesitant to choose careers in engineering and science, and many educational institutions elected to cut back their graduate programs.

At M.I.T., we regarded these moves as serious errors, and chose to exert our leadership through support of a continuing high level of research and a scientifically based education. As the world's leading Institute of Technology, we felt a very special responsibility to identify the continuing value of engineering and technology in our society. At the same time, we felt an important obligation to maintain a major visible commitment to fundamental research, the creation of knowledge for its own sake. We took as our institutional obligation the support of these two propositions in a time of challenge.

In many ways this meant simply doing what we had been doing, in a new context and with strong determination. The challenge was to continue and intensify our efforts in the face of widespread skepticism and even antagonism, to relate our efforts to the problems of society and industry created by the forward sweep of technology, and to address people's growing concerns about whether the resulting world truly serves them well.

This year we are pleased to report some positive results of the planning and hard work of our colleagues throughout the Institute. The problems by no means have disappeared, nor are they likely to do so in our lifetime. However, we believe that we are going in the right direction. During the past year, we have seen a variety of activities develop beyond their formative stages, assuming more mature and integrated roles in the life of the Institute. We are pleased that these newer efforts are holding their own and are beginning to make substantial contributions to M.I.T.'s educational programs, to our understanding of the complexities of modern life, and to the improved management of our society. We are equally pleased that these new activities have been built, in large measure, through initiatives that stem from M.I.T.'s established departments and Schools. At the same time, the core programs are in a healthy state of flux, as exciting new research is undertaken and teaching programs are adapted to current intellectual interests. These achievements are documented in detail in the reports of our colleagues, the Provost, the deans and department heads, the vice presidents, and the laboratory and center directors. We will note the highlights in later pages of this Report, but wish to express here our appreciation of the efforts of all those at the Institute who have made those achievements possible.

This Report is, in effect, a snapshot of the year past, in which we present a summary of some of the major events of 1973–74. We wish at the same time to convey a sense of continuity within change—to examine the links of the past and future in the present. For this purpose, we have devoted a portion of this Report to an extensive discussion of the evolution of undergraduate education at M.I.T. during the past 15 years. To provide an even broader frame of reference, we have included an appendix prepared by the Provost and several of his associates. This appendix, containing a series of charts, indicates some patterns of growth and change at M.I.T. over the past 30 years—in physical size, in population, and in the number and range of activities. As we feel a quickening of the stride of the Institute into the seventies, we recognize our deep indebtedness to those who have built this institution and made it strong.

* * * * *

MIT always has been a remarkably timely institution. Throughout its history, the intellectual problems it has addressed, the style of its education, and its mix of theoretical and applied arts have been at the cutting edge of our society's most pressing contemporary issues. One sign of the timeliness an M.I.T. education offers is the strength of undergraduate and graduate applications to the Institute. Both the number and the quality of applications remained high during the recent period in which other colleges, and especially schools of engineering, reported declining applications. They remain strong today. Last year, for example, we had 4,417 final applications, a 20 percent increase over 1972–73. Although we intended to hold the size of each class to approximately 1,000, primarily because of limitations in our ability to provide adequate dormitory space, significantly more students in the Class of 1978 accepted our offer of admission than we had anticipated. This will create some overcrowding in the residential system during the next year, but it also bears witness to the attractiveness of an M.I.T. education for both young men and young women. Graduate applications also have risen, although the number of students we can admit and the number who can come continue to be affected by the difficulty of obtaining financial support.

After several months of extensive discussions, this year the faculty approved a new form for the undergraduate humanities requirement, which is now called the Institute Requirement in the Humanities, Arts, and Social Sciences. The new Requirement still consists of eight term subjects, but now includes a distribution requirement in a range of areas, a small core of concentration in one aspect of humanities, the arts, or social sciences, and several electives. The overall objective is to

engage students in important ways of thinking and modes of expression not commonly encountered in science and engineering subjects, and to foster that integration of perspectives on which effective, responsible work in science and technology depends. The depth and spirit of the discussions which led to a new requirement to help meet this goal bear witness to the importance of its role in an M.I.T. education.

The contemporary nature of an M.I.T. education, as well as its interrelation with research and industry, is illustrated by new developments in the School of Engineering. That School has just received a major grant from the Alfred P. Sloan Foundation to identify new and different subject offerings and degree programs, to support different kinds of problem oriented research, and to develop continuously new areas of social concern. These new research efforts and the related educational programs are aimed at understanding the complex operations of a technological society. They will build on engineering science and will emphasize technology in relation to the social, economic, and value systems of the society, with special emphasis on major functional sectors such as construction, transportation, manufacturing, and the delivery of a variety of essential services. The undergraduate program will bridge the humanities, the social sciences, and engineering, and will draw support from all the Schools of the Institute.

Similar interdepartmental and inter-School collaborations have developed around a number of timely issues in health related fields, the sciences, nutrition planning, and the interconnected problems of energy and environment. Because of the close connections between these research and educational programs and the concerns of a wide range of industries, government agencies, and service providers, existing avenues for collaboration are being strengthened and imaginative new ones are being developed. For example, undergraduate participation in cooperative programs, in which the student spends several terms working in a company or agency on successively more sophisticated research, is increasing. Applications to the cooperative program in the Department of Electrical Engineering, for example, were up to 116 this year, from 39 four years ago. During the same period, the number of spaces available for new students in participating private companies and government agencies has grown from 29 (in 1970) to approximately 65 (in 1974). The similar growth in other departments' cooperative programs and the success of the Undergraduate Research Opportunities Program's off-campus placements also attest to the continuing viability and mutual benefit of this mode of education.

M.I.T.'s efforts to combine intellectual work, public service, and education in the fields of energy and technology policy have been consolidated and strengthened by the development of two new laboratories in these areas. The Energy Laboratory has three broad goals: to identify and work toward short-term and long-range solutions to energy related problems, emphasizing those requiring broad interdisciplinary capabilities; to provide comprehensive and objective assessments which can become the basis for public policy; and to strengthen research and educational opportunities in energy related areas at M.I.T. The Laboratory was in a very good position to respond to a suddenly increased need for analysis when fuel problems became critical last fall. Several M.I.T. faculty members associated with the Energy Laboratory worked intensively on short-range studies to help the Federal Energy Office develop supply and allocation policies for dealing with the immediate crisis; in addition, they have done a somewhat longer-range policy study exploring means to assure growing and continuing energy supplies, particularly of petroleum, for the nation.

Research in the Energy Laboratory has been sponsored in special areas by contributions from industrial supporters and utilities, as well as by foundations and the government. These contributions include substantial longer-term funding that enables us to build a national facility capable of carrying out large-scale studies, which the nation desperately needs and to which we believe M.I.T. should contribute.

The Center for Policy Alternatives, established within the School of Engineering in 1972, has a comparable responsibility. The Center's primary function is to identify the major technology related issues facing society, to assess the consequences of present policies and practices, and to develop alternative actions which will improve society. In its two years of existence, the Center's annual research support has grown from $60,000 to approximately $1.5 million; its staff has grown from three people in 1972 to providing partial support for over 15 faculty members and 30 graduate students from throughout the Institute, as well as supporting its own professional staff. Among the wide spectrum of the Center's studies, one on the hidden costs of consumer appliances received major attention during the past year.

Another new and promising effort is the Division for Study and Research in Education. Through this new Division, we are building a group of people who will work on the extremely difficult, fundamental questions of learning and behavior, which up to now have proven quite intractable. By the end of its first year, the Division had made significant progress in identifying those aspects of learning, and those contexts in which learning occurs, which seem to provide the most promising avenues for investigation. A major hypothesis which the Division is investigating is that the effectiveness of a learning process—whether in a person, an institution, or a computer—has much to do with how information and procedures are represented, retrieved from memory, and modified. If this is true to a significant degree, then studies of these very different learning situations should be mutually enhancing. Such investigations are rich in connections to the educational concerns of faculty and students throughout the Institute, and the Division offers the potential for a variety of collaborative arrangements which could influence the effectiveness of our educational programs—all too rare an occurrence in the intellectual life of most universities.

While M.I.T.'s faculty and students in interdisciplinary groups, new and old, are addressing themselves with some success to major functional issues in our society (with the indispensable collaboration and support of government agencies, private foundations, and the relevant and affected industries), basic research in a variety of fields has been equally productive.

For example, fundamental breakthroughs have been made in our understanding of the biological substrates of life. In August, 1973, M.I.T. scientists announced the synthesis of a

126-unit gene, the first ever synthesized with the potential for functioning detectably in a living cell. Although the code by which genetic information is transcribed into working molecules is well known, only now is it possible, by synthesizing chemical start and stop signals and attaching them to the synthetic gene, to explore how this transcription is controlled by the cell.

Work which builds on already strong research groups in biology, chemistry, and biochemistry is under way in the new Center for Cancer Research. In the past few years, it has been discovered that chemical changes take place on the surface of cells when they become cancerous, and the changed chemicals have been identified. Immunologists at the Center have established that once the surface substances have been identified, one can make an animal reject its own cancer cells. Finally, an enzyme has been discovered that acts as a catalyst, converting the genetic material of a virus into DNA which can enter the genetic material of a cell and make it cancerous. While the Center for Cancer Research is currently a relatively small facility, its fundamental theoretical work is producing increased knowledge of how cells become cancerous, what goes wrong in cancer cells, and what abnormalities are due to the action of viruses.

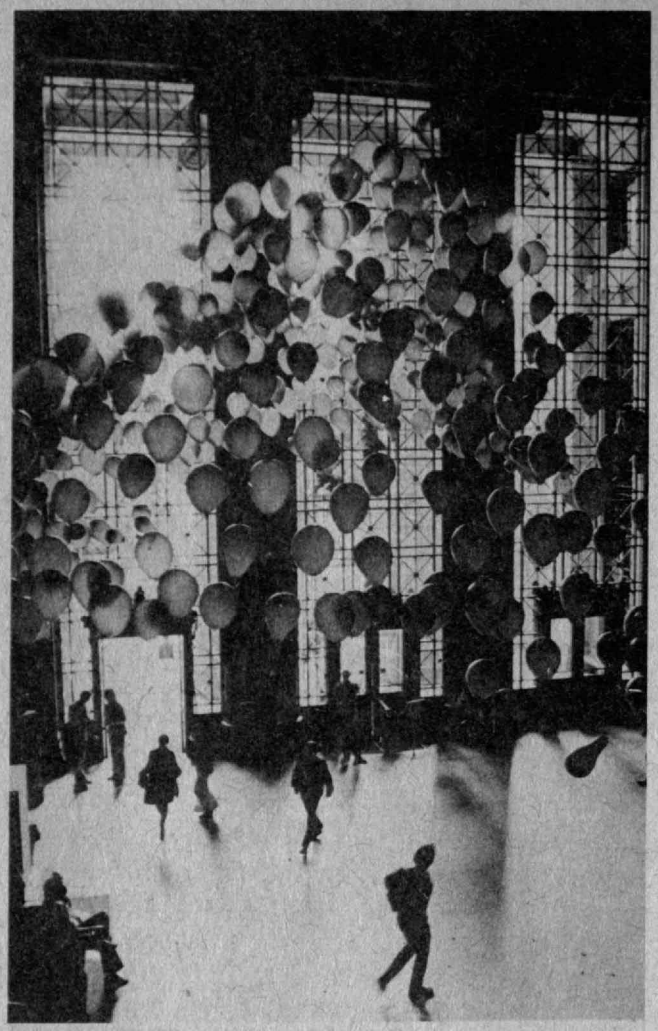
Just as significant breakthroughs in molecular biology have been made possible by the discovery of the double-helix structure of DNA, so the development of plate tectonics has provided significant impetus in the geological sciences. According to this theory, the earth's outer surface is composed of 12 plates, each roughly 100 kilometers thick. These plates, on which the continents float, are in constant motion, sliding by each other, colliding and separating. Most large-scale geological phenomena—earthquakes, volcanos, and large mineral deposits, including oil—occur at the boundaries of these plates; some are caused by their motion. For a number of years, M.I.T. scientists, in collaboration with the Woods Hole Oceanographic Institution, have been exploring the details of plate motion and investigating its practical consequences for earthquake prediction, the discovery of mineral deposits, and the study of other phenomena.

In the field of radio astronomy, M.I.T. scientists discovered this past spring a new and completely unexpected celestial source of radio emissions. This source, imperceptible by optical methods, is detectable only in the 0.1 to 1 millimeter range of wavelengths. It emits a signal one-tenth as strong as the moon's, indicating the presence of a class of significant and previously unknown phenomena outside our solar system. This discovery is an interesting repetition of the history of modern astronomy, when opening a new band of observation revealed unsuspected phenomena. At longer radio wavelengths, quasars, pulsars, and radio galaxies were dramatic examples of objects completely different from familiar ones; when X-ray detectors were carried above the Earth's atmosphere, X-ray stars were discovered, posing entirely new astronomical questions. The nature of the new class of source is a complete mystery so far, but history gives one confidence that interesting and important physical phenomena will be revealed.

A final example of ground-breaking scholarship is in mathematics, and concerns one of that field's most famous unsolved problems—the so-called Riemann hypothesis. Certain unproved mathematical conjectures of long standing have played a major role in the development of the discipline, because they are rooted in fundamental questions, are tantalizingly difficult to prove, and because the attempt to prove them generates new and exciting mathematical concepts and tools. The Riemann hypothesis is just such a conjecture within the field of analytic number theory. Since 1859, an uninterrupted string of mathematical giants has attempted to prove the Riemann hypothesis, and, while unsuccessful, their attempts have generated an enormous amount of new and interesting mathematics. During this past year, Professor Norman Levinson has made the greatest progress to date toward proving this famous hypothesis, showing that more than one-third of the zeroes of the Riemann zeta function lie on the line $\mathrm{Re}(z) = 1/2$.

A very different but equally important contributor to the liveliness and contemporary flavor of M.I.T. has been the work of the Council for the Arts. Just completing its second year, the Council now has established itself as a fully functioning unit of the M.I.T. community, having developed an operating staff and a modus operandi which should see it through many years to come. The Council's role is to some degree that of magnifier—providing grants and helping to find support for a variety of faculty and student projects throughout the Institute, as well as initiating its own activities. Through its efforts, we envision a decade of growth and development in one of humanity's oldest, yet newest, endeavors. Worldwide, the arts are moving out of an era of private patronage and into an era in which increasingly they are practiced and appreciated in many parts of our lives. We are by now quite familiar with the ideas of economic and social development. However, it is becoming possible to speak also of cultural development, and to do so in terms that have the sort of clarity demanded by interdisciplinary problems. If society is beginning to become serious about cultural development, it will need models as the precondition for knowing how to proceed. It is precisely here that M.I.T. can make its unique contribution. Not only is participation in the arts an especially appropriate, lively, and popular part of the lives of many of our students, but M.I.T. is also in the process of developing active, broadly based, participatory programs in the arts. These programs, which are founded solidly on teaching, practice, and research, may help our society to invent a process for melding cultural development with its social and technological progress.

We at M.I.T. remain committed to the proposition that education, science, technology, and art, broadly conceived and used in the service of a free, democratic society, remain basic ingredients of genuine human progress and happiness. We see ahead a new era of understanding and caring in the relationships among people, their environment, and their society—an era in which technology is responsive to broad social and environmental needs, as well as to individual material needs. M.I.T. has important contributions to make, and is in a strong position to do so. However, our most important contribution will be our ability to foster the best in our students. The most important resource of the future will be these young people—



Environmental Art in the Rogers Lobby: "Balloon Carpet" by Otto Piene.

intelligent, concerned, alerted to the nature of the issues at hand, and equipped with the best intellectual tools available.

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Undergraduate education at M.I.T. is an inseparable part of a large, complex, and exciting system composed of teaching at both the graduate and undergraduate levels, research, and a variety of relationships with society at large. In this dynamic environment new research programs, such as those in energy and biomedical engineering, markedly broaden the opportunities and choices available to the undergraduate student. Moreover, reconceptualization of a field at an advanced research level can have at M.I.T. immediate and beneficial consequences for related undergraduate programs; conversely, new developments and patterns in undergraduate education can influence graduate education and research activities deeply. To consider undergraduate education as a separate topic, as we do here, is clearly an oversimplification. However, the past 15 years have been a time of heightened change and ferment in undergraduate education at M.I.T., a time of experiment and response to an evolving world, and it is now appropriate to focus specifically on the extent and nature of these changes, tracing their origins and exploring probable future directions.

Several major influences on the evolution of undergraduate education at M.I.T. during the past 15 years are especially striking. Since the late 1950s, we have witnessed significantly improved and more intensive preparation in many secondary schools. (M.I.T. itself played a major role in this national development.) This has made for greater diversity of preparation among students entering M.I.T. At the present time, for example, approximately one-half of the entering freshman class already has had a year of calculus in secondary school, which produces a range of appropriate "starting points" in the mathematics program. Similar differences in level of preparation and area of student interest occur in the sciences and in the humanities. Furthermore, M.I.T. appears to draw an increasing fraction of its entering students from a group of applicants that it shares with major liberal arts universities. These young people, highly capable in mathematics and the sciences, look to us for a first-rate education which can help them develop a wide range of interests.

In addition, faculty members' and students' perceptions of students' future career patterns have been changing. Increasing numbers of students go on to graduate or professional school, yet at the same time, fewer undergraduate students wish to make an early exclusive commitment to a single career path. As a consequence, both faculty and students value the opportunity for sampling career possibilities. For many stu-

dents, such experience also provides the motivation that comes only from genuine involvement with real problems.

Finally, fields and disciplines have continued to evolve, both as knowledge has developed and as patterns of external problems and needs have changed. In particular, increased concern with problems generated by technology itself has been a notable influence on our educational programs.

In the presence of these and related influences, faculty members in all fields at the Institute have provided vigorous and imaginative leadership in a continuous evolution of the undergraduate program. This leadership has been evident in ongoing debate and formulation of policy in faculty meetings and by faculty committees such as the Committee on Educational Policy (C.E.P.); it has been evident in special studies of education such as the Committee on Curriculum Content Planning, the Commission on M.I.T. Education, and the Special Task Force on Education; and most important, it has been evident in the evolution of departmental programs, in the teaching of individual subjects by individual faculty members. Students, as members of faculty committees and participants in faculty meetings, have made increasingly significant and effective contributions to these developments. We believe that throughout this recent period, the M.I.T. faculty has been second to no other university faculty in the energy, creativity, discrimination, and commitment they have brought to the exploration of new approaches and directions in undergraduate education.

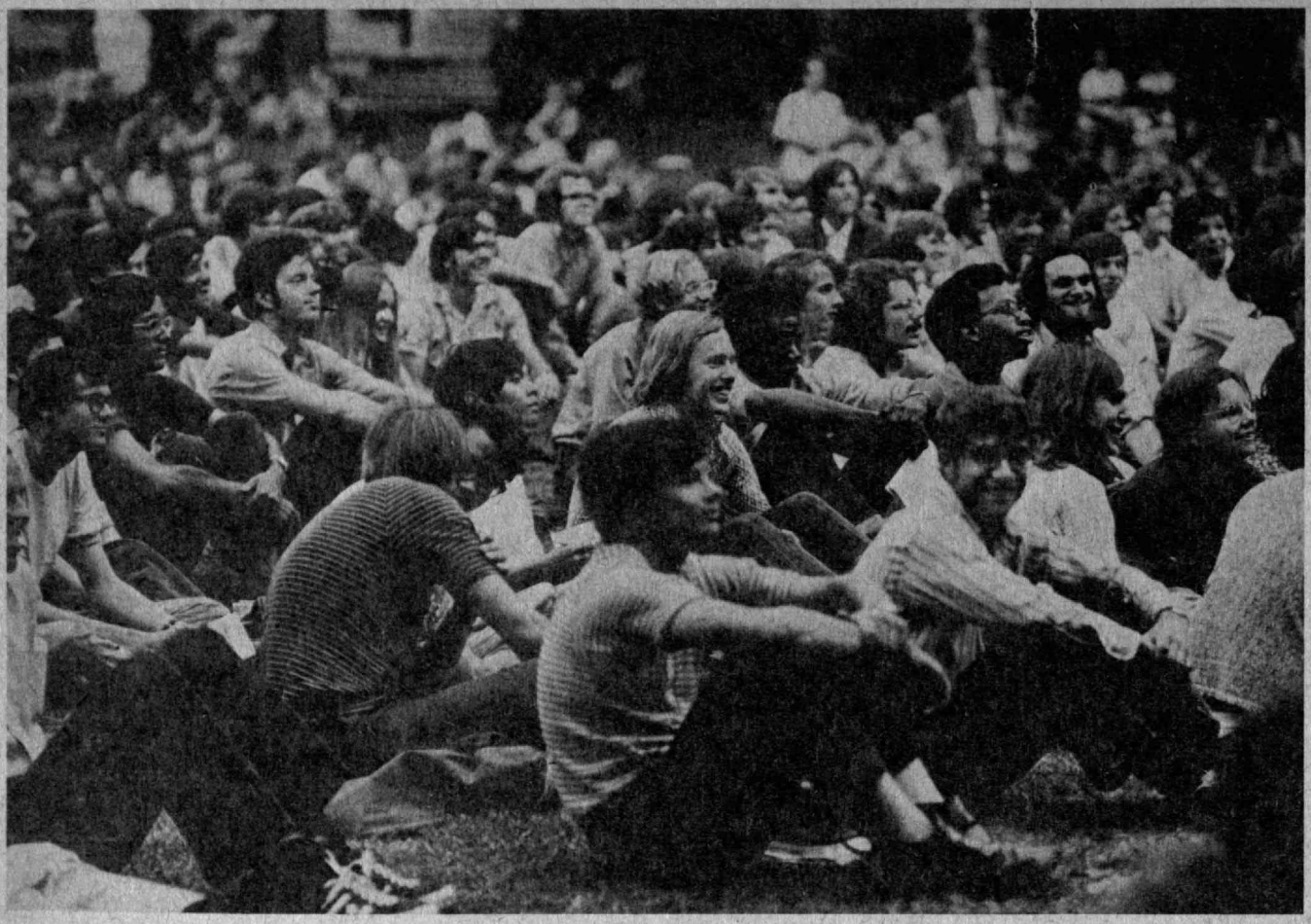
Through it all, a sense of continuity with the past has remained strong. The Institute maintains and indeed cherishes its distinctive character and atmosphere as a university of "science, engineering, and the arts." The commitment to excellence, to hard work, to learning by doing, is as evident at M.I.T. today as it ever has been in the past. The early exhortation of William Barton Rogers to maintain the highest intellectual quality while seeking useful knowledge remains a guiding principle in the formulation of our educational programs. Undergraduate programs continue to be departmental and "professional" in format. The general balance of student interests is as before—traditional disciplines in science and engineering continue to draw a major share of undergraduate students—although the balance of interests and emphasis among these disciplines has changed in important ways. The most significant of these may be the great interest in the life sciences and in societally related aspects of science and engineering. Perhaps most important of all, both students and faculty continue to find inherent satisfaction and reward in the intellectual activity of learning and research.

However, changes have been made—changes which translate M.I.T.'s traditional educational values into modern terms, capable of engaging and challenging today's students. As an overall pattern, these changes have added considerable variety and flexibility to the undergraduate program. The form and structure of the Institute core requirements have been modified to permit increasingly varied paths and programs, while retaining an emphasis on basic principles and on experience in science, technology, and the humanities. For example, it is possible to take a version of freshman physics that is oriented toward the biological sciences or one that is highly theoretical, instead of the regular one. Similarly, in introductory mathematics and chemistry the student has several choices, and some of the subjects can be studied in a variety of styles—self-paced, in a seminar-tutorial mode, or in the familiar lecture-recitation mode. Pass/fail grading has been introduced in the freshman year to facilitate adaptation of new students to the Institute, and to provide a less competitive atmosphere for them to stretch their minds freely and explore new subjects. (A limited form of pass/fail also exists in the upperclass years.)

In a similar vein, flexibility in upperclass departmental and interdisciplinary programs has been increased significantly. The Interdisciplinary Science Program (Course XXV) was introduced several years ago in the School of Science; it leads to a bachelor's degree without specification of professional field. Students in this program, in consultation with faculty, can design individual courses of study in science that have a wide variety of forms and emphases. Several departments across the Institute also offer programs leading to degrees that do not specify a major field. These programs permit the student to arrange rather general courses of study within the setting of a department. At the same time, departmental programs leading to a degree that specifies a major field also give an increased measure of elective freedom to students, who may take subjects both within and outside their major field. One measure of increased upperclass flexibility is that at the present time, almost one-fifth of all undergraduates choose to select a major field of study later than the beginning of the sophomore year.

New and welcomed flexibility for both faculty and students also has been achieved through the shift of the academic calendar so that the first term ends before Christmas vacation, making possible the three-and-one-half-week Independent Activities Period in January. Into this short period is crowded an aggregation of some 600 mini-courses, problem focused seminars, intensive versions of regular academic offerings, and imaginative exotica which provide engaging opportunities (such as building the world's largest yo-yo). I.A.P. provides an exciting change of pace, a midwinter rejuvenation which is good for the mind and the soul.

In keeping with the strong professional orientation of M.I.T., the faculty has been exploring a variety of new ways to provide an early introduction to professional atmosphere and to problem oriented experience. Laboratory work now emphasizes longer-term projects; a variety of field-work opportunities are available as part of regular departmental programs; the Undergraduate Seminar Program provides elective introductory subjects in informal, small-group settings; cooperative programs continue to give intensive field experience in an off-campus setting; and the Undergraduate Research Opportunities Program (U.R.O.P.) provides a framework within which the student who wishes to can participate (in any given term) in a research experience, on- or off-campus, that will stand as the equivalent of one or more subjects taken in that term. Such collaborative work provides the undergraduate student with a close association with a faculty member, a situation we have been most anxious to achieve. At the present time, in any given term, approximately one-half of the faculty



M.I.T. students.

and approximately one-half of all undergraduate students are engaged in activities under this latter Program.

The diversity of interests among our students also has suggested the usefulness of educational collaboration with other institutions. One example is the Wellesley-M.I.T. Exchange Program, which began in 1967. Under this program, undergraduates at each institution may take subjects at the other, and participation this year included 337 M.I.T. students and 446 Wellesley College students. The program offers a richer and more varied educational atmosphere to students at both institutions, including opportunities for increased joint participation in such extracurricular activities as the M.I.T. Symphony and the Wellesley Chamber Singers. It is hoped that an increased amount of faculty collaboration also will become possible. A cross-registration program, more limited in scope, also exists between M.I.T. and Harvard University for undergraduate and graduate students at both institutions. Finally, the Program in Health Sciences and Technology, sponsored jointly by M.I.T. and the Harvard Medical School, provides the first two years of professional medical education for students who seek a program with special scientific and technological emphasis. This program accepts approximately 25 students each year. M.I.T. students may apply for admission at the end of their junior year. After the two-year joint program, students take their final two years of medical education at Harvard Medical School and receive the Doctor of Medicine.

Throughout recent years, both faculty and students have given continued attention to the vital role (both formal and informal) of humanities, social sciences, and the arts in undergraduate education. Earlier in this Report, we described the new Institute Requirement in Humanities, Arts, and Social Sciences. The change in formal requirement is a reflection of increased concern on the part of both faculty and students for the development of new and more varied ways in which to become engaged with social and humane issues. Another symptom of this interest is the burgeoning of activities in drama, music, creative writing, and the visual arts. All bespeak the vital connections among science, technology, society, and culture.

Our survey of recent changes in M.I.T.'s undergraduate education is nearly complete. However, it has not conveyed yet one of the more important but subtle changes in educational atmosphere that has occurred—the increasingly collegial role that students have come to play in the educational and research life of the Institute. This has been a wholly beneficial development. It provides an educational atmosphere that is highly favorable and that holds potentials we are only beginning to explore.

In addition to continuous efforts to modify the academic

program so that it retains the unique strengths of M.I.T.—equal dedication to excellence *and* to contemporary issues—we also have kept in mind that for undergraduates, M.I.T. is a home, a 24-hour-a-day community. Some aspects of this community should lend themselves to rest, play, and congenial company. Others should supplement the intellectual activity which is represented by formal course work, problem sets, and exams. The peer community in which a student lives and works is particularly important in these respects, and we regard the housemaster-tutor system, begun in 1951 and well under way by the late 1950s, as a particularly valuable bridge between life in student living groups and the academic enterprise. Similarly, recent alternative programs for freshmen, such as the Experimental Study Group (E.S.G.) and Concourse, have given ample demonstration of the potential and value of small peer groups based on shared intellectual interests and experiences.

While providing a supportive milieu which enhances educational experiences is a general goal for the Institute, it is of particular importance to the minorities and women who study here. M.I.T. is striving to become more nearly a community where no preconceived bounds are set on the capabilities or potential contributions of its members. The Class of 1978 includes 20 percent women and 5 percent minority students, and we look forward to significant increases in these groups in the future.

Most of the recent developments in undergraduate education had their origins in the early and middle 1960s. In the late sixties, the time of student unrest across the nation, the flux of experiment and innovation continued at M.I.T. In the past two or three years, as we engaged in a more general stocktaking and sorting-out, many of the new educational efforts were judged to be of enduring worth, and consequently have been kept. We have mentioned the most valuable of these. Others were judged not to be of long-range value, and have been phased out.

It will be no surprise that many vexing questions remain. Exploration of new approaches and directions, of course, will go on. Such work is a major part of the continuing process by which each generation of faculty and students renews itself and its commitment to the educational mission of the Institute. We hope to be guided in these efforts by our recent experience, and expect that some of the issues before us will be natural projections of concerns and issues which are emerging from that experience. For example, are there other ways in which the Institute, within the present general framework of educational programs and research interests, can provide an undergraduate student with an early introduction to professional atmosphere and research experience? Are there ways in which the Institute can acquaint a student with a variety of possible areas of career choice? The success of the Undergraduate Research Opportunities Program and of the Independent Activities Period may provide helpful guides.

The change in the humanities requirement doubtless will result in many new subjects becoming available to students. During the period in which the logistics of its operation are being worked out and the range of distribution and concentration subjects is being refined, how can we best take advantage of the opportunity to help our students grasp not just the letter of the requirement, but also its spirit—the development of a deep commitment to nonquantitative ways of thinking, and to an understanding of humanity? In particular, how can we foster those writing skills on which communication in all fields depends?

How can we continue to ensure that undergraduate programs keep pace with the reconceptualization of academic fields? Such reorganization, often along problem oriented lines, is an important academic concern of the Institute at the present time. A related question is the extent to which interdisciplinary programs for the individual student should be encouraged and formalized. We are most enthusiastic about the School of Engineering's current exploration of this range of issues in undergraduate engineering education.

Given the diversity of students and the diversity of possible careers, what is the best possible form for academic advising and counseling? Advising and counseling at M.I.T. occur under a variety of circumstances at a variety of places and times, as they should. At present, we judge our efforts to be inadequate. How can we tap better the human resources of faculty and staff in support of the advising process? Can we understand better the nature and extent of the academically related advisory needs of minority students, women students, and prelaw and premedical students? What is the role of peer groups and small learning groups in providing support, a sense of collegiality, and a source of continuing advice in a relatively large and increasingly diverse university?

Finally, the formal structure of academic requirements and procedures are not the body and substance of education, but they are the skeleton upon which the body takes its shape. They remain a major subject of faculty and student deliberations. Among such formal issues are the following questions: What is the meaning of the general escalation of grades? Should M.I.T.'s current grading systems be revised or modified? (A special faculty-student committee on grades will report this fall.) What parts of a student's educational life at M.I.T. merit formal academic credit, and how should such credit be measured? To what extent should credit be given for academic activity off campus, and to what extent should exchanges or joint programs with other institutions be fostered? Can the present balance of prescription and elective choice within our undergraduate program be improved?

We anticipate further discussion of these concerns and issues during the coming year, and most likely will discover new ones. Our ability to maintain an Institute-wide perspective on these issues will be enhanced by the establishment of the position of Associate Provost, and particularly through the talents and experience of its incumbent, Professor Hartley Rogers, Jr., who has been involved deeply in helping the faculty to consider continually the effectiveness of its efforts. We believe that M.I.T. now has undergraduate programs of outstanding quality, substance, and value. The developments of the past 15 years have brought much of enduring value, and the past year has seen a consolidation and a sorting-out of substantial proportions in our programs. Much remains to be learned and done, however. Both the Institute and its students must continue to explore and grow.

It seems fair to say that investments in M.I.T.'s intellectual and educational future made over the course of the past few years were extremely worthwhile. However, these investments, in the form of time, energy, new materials, equipment, and space, and most importantly people, have been made in the context of increasing financial stringency for the Institute. In financial terms, the year was a difficult one. The relentless pressure of inflation on the cost of operations increased dramatically, and our planned efforts at cost control proved insufficient to preserve the delicate balance that has held for the past several years.

The effect of inflation on expenses was compounded by unusual restrictions on the recovery of indirect costs from Federal research sponsors. These restrictions, which were agreed to in 1972 as part of the plan for the divestment of the Draper Laboratory, applied only during 1973–74, when they produced a shortfall of approximately $2.8 million in indirect cost recovery. As a result of these factors, a large operating loss experienced by The M.I.T. Press, a loss associated with the Turnkey project in housing for the elderly in Cambridge, and a modest decline for the year in the flow of unrestricted gifts, the operating budget showed a deficit (after application of current unrestricted gifts and income) of approximately $1.5 million, or approximately 0.8 percent of the expense budget for the year. Both this deficit and the shortfall in indirect cost recovery were funded by drawing on unrestricted reserves of the Institute.

The impact of inflation, and the form of our response to it, are illustrated well by the effect of the "energy crisis" of last winter on M.I.T. operations. The Institute is an intensive user of energy, in the forms of electricity and of oil and natural gas, which are used for heating and air conditioning. Since October, 1973, the unit cost of electricity has nearly doubled, while the unit cost of oil has tripled. As a result, the cost of utilities for the year exceeded the budget by approximately $0.9 million, or 27 percent. Because of the limitations on indirect cost rates for the year, none of this increase in cost could be recovered from research sponsors. The increase would be even larger were it not for heroic efforts at energy conservation throughout the Institute. Such measures allowed the Institute to operate normally under a 75 percent allocation for fuel oil, and reduced the operating deficit for the year by approximately $0.8 million from what would have resulted had energy utilization not been curtailed.

The energy budget for 1974–75 is, in spite of effective conservation measures, nearly twice that of 1972–73. This enormous cost inflation, coupled with the possibility of future oil and gas shortages, requires that we continue to give attention to ways of reducing the use of energy at the Institute.

Our current budget plans include a small deficit for 1974–75 as well, although the return to full rates for the recovery of a share of indirect costs will prevent a repetition of the shortfall experienced in the year just ended. It had been our intention to have a balanced budget in the current year, but it appeared unwise to exert the degree of cost control which would have been necessary to absorb the sizable cost increases caused by the extraordinary escalation of inflation and energy costs. We begin preparation for the budget process for 1975–76 with the intent of developing those processes which will restore the budget to balance, and of making available for capital purposes a significant portion of the annual flow of unrestricted gifts.

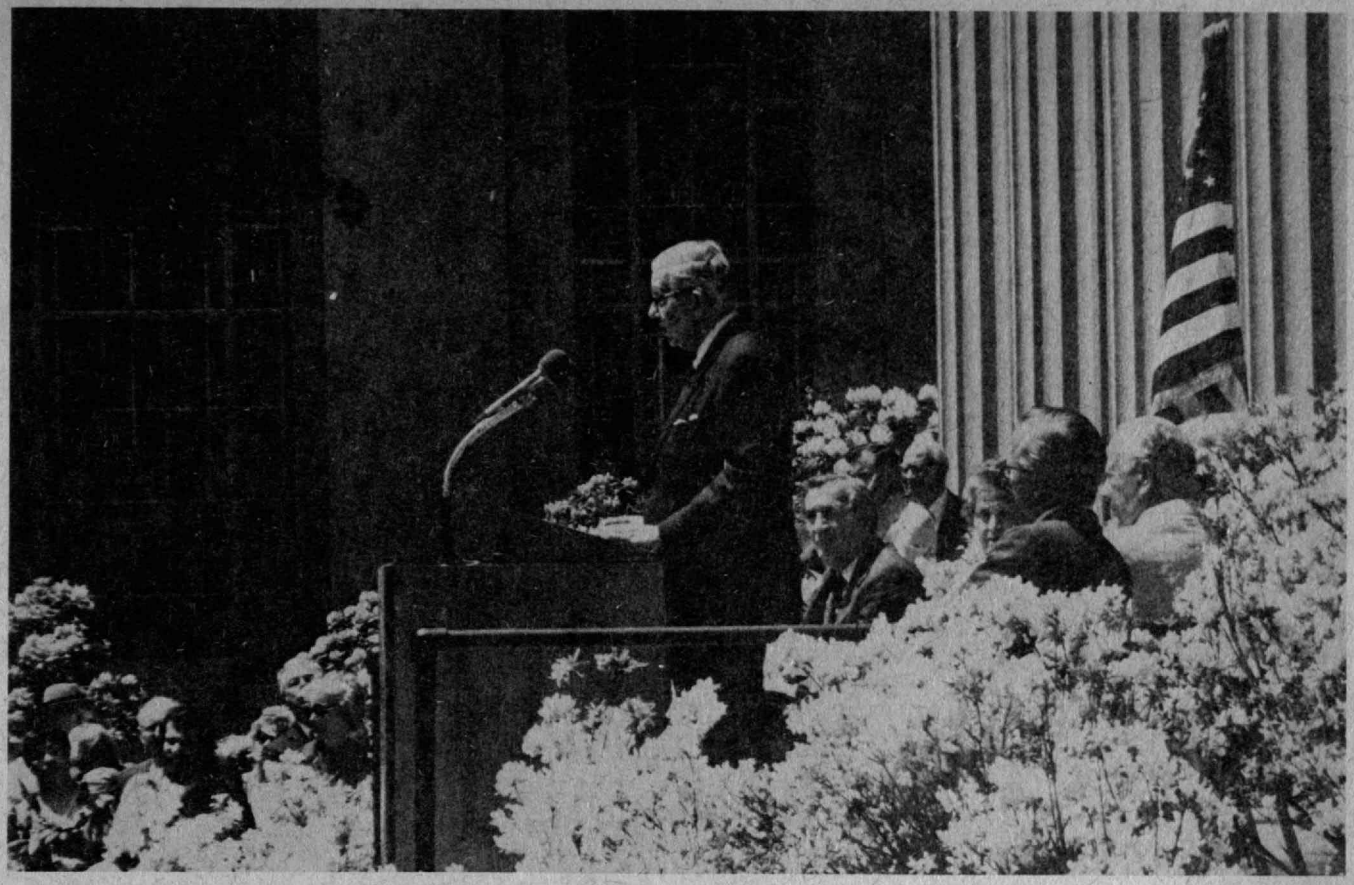
Despite financial difficulties of the moment, the Institute is financially sound, and will remain so if we take strong measures now. It is intellectually and educationally first-rate. Our future contributions will depend on insightful development of our intellectual and educational resources, coupled with determined efforts to protect our financial strength. We can invest in the intellectual future and simultaneously strengthen our financial base in several ways, expanding the capacity of the Institute to contribute to new areas of research activity and making M.I.T.'s unique education available to more young people. To this end, we are considering seriously a variety of new options: expanded cooperative programs, a new master's-level program in applied science, and expanding enrollments to the extent that undergraduate housing and graduate-level financial aid permit. We must renew our efforts at cost control and cost reduction, eliminating those activities which are no longer central to our educational purpose and supporting the academic activities of the Institute as efficiently as possible. In support areas, we will focus on the purpose of each activity, consider alternatives, and with our colleagues in each area, take a hard look at priorities. In academic areas, we will encourage reexamination of the present utilization patterns of money, people, and space, with the recognition that we must consciously redirect existing resources.

Finally, we must redouble our efforts to seek new levels of private gift support, which is crucial in securing the future independence and vitality of the Institute. We plan to undertake a broadly based appeal for capital funds, similar to the Second Century Fund of the early 1960s, but focused on increasing M.I.T.'s endowment and on ensuring adequate support for those research and educational programs for which we are uniquely suited.

We believe that M.I.T. is in a unique position to help a society plagued with interrelated energy and environmental problems, the challenge of controlling technology, and unprecedented inflation rates which wreak havoc on all sectors of the economy. We emerge from our years of searching with a sense of optimism. This optimism is based in part on the successes of the past few years, on the opportunities in research and education which our efforts have opened up, and on the spirit and quality of the young people we live and work with.

As we close our remarks for this year, we would like to pay special tribute to two men whose unique contributions to M.I.T. were noted on two occasions during the past year.

The first was an occasion of celebration—the Corporation's Resolution to name M.I.T.'s Great Court in permanent honor of Dr. James R. Killian. As noted in the Resolution and affirmed by the warmth of the ceremony held in the Court, for 25 years M.I.T. has "looked to him for exceptional poise, unity, and sense of direction which have enabled M.I.T. to move forward with giant strides and high confidence." The Great Court has existed for slightly more than the 50 years of Jim



Dr. James R. Killian, Jr. speaking at the Dedication of the Killian Court.

Killian's association with the Institute, waiting for a felicitous name. Jim Killian and the Great Court, with its serenity, beauty, and affirmation of life, appropriately honor each other.

The second occasion was one of sadness—the death of Dr. Vannevar Bush. Much was written at the time of his death late in June, 1974, and we cannot hope to equal, in eloquence or feeling, the many tributes already paid. Suffice it to say that Van Bush carried with him an enormous vision of the role of science in the life of modern humanity; in his words:

Science by itself provides no panacea for individual, social, and economic ills. It can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress, no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world. . . .

M.I.T. owes much to each of these men. We find in their long and varied careers the essence of the Institute—reborn with each generation, changing in some ways with each decade, but preserving an essential spirit, a dedication to excellence, to inquiry, and to renewed efforts on the side of humanity. As we have noted achievements of the past year, as we evaluate our attempts to define a first-rate contemporary education, and as we come to a fuller realization of the necessity of protecting the quality of M.I.T.'s life by putting it on a firmer financial foundation, we are impressed continually with the legacy of strength that has been given to those at M.I.T. today, and we are determined that it shall be continued.

* * * * *

IN SPECIAL RECOGNITION

The individual efforts and distinctions of faculty members at M.I.T. have been many during the past year, and cannot be enumerated in full here. We do wish to take note of the election of six members of the faculty to the National Academy of Sciences, six to the National Academy of Engineering, and 11 to the American Academy of Arts and Sciences. These elections, and numerous other honors and awards, attest to the continued high quality of the M.I.T. faculty and to the dedication of its individual members to scholarship of the highest order.

Of special note during the year were the appointments of three members of the faculty to the distinguished rank of Institute Professor: Dr. Philip Morrison, Professor of Physics; Dr. Walle J. H. Nauta, Professor of Neuroanatomy in the Department of Psychology; and Dr. Robert M. Solow, Professor of Economics. Also of special note was the second presentation of the James R. Killian, Jr. Faculty Achievement Award, to Institute Professor Victor F. Weisskopf. Special honor was paid several faculty members through their appointment to newly established distinguished professorships. Dr. John S. Waugh is the first Arthur Amos Noyes Professor of Chemistry; Dr. Hermann A. Haus, the first Elihu Thomson Professor of Electrical Engineering; Pierre Raoul Aigrain, the first Henry R. Luce Professor of Environment and Public Policy; Dr. Francois M. M. Morel, the first Henry L. Doherty Assistant Professor of Ocean Utilization; Dr. Seymour A. Papert, the first

Cecil and Ida Green Professor of Education; Dr. Robert W. Mann, the first Uncas Whitaker Professor of Biomedical Engineering; and Dr. John G. King, the first Francis Friedman Professor of Physics. The initial incumbent of such a distinguished chair is especially honored for outstanding achievements to date; in turn, through his or her continued achievements, the incumbent honors the name of the chair itself.

The past year saw several appointments to senior posts that should receive special mention. Professor Wilbur B. Davenport was appointed Head of the Department of Electrical Engineering; Professor Jule G. Charney, Head of the Department of Meteorology; Professor Myron Weiner, Head of the Department of Political Science; Professor Herbert H. Richardson, Head of the Department of Mechanical Engineering; Professor Langley C. Keyes, Head of the Department of Urban Studies and Planning; and Professor Michael L. Dertouzos, Director of Project MAC. Dr. Hartley Rogers, Jr., Professor of Mathematics and past chairman of the faculty, was appointed Associate Provost.

The past year also marked the retirement of 12 members of the faculty. Their long and dedicated service to M.I.T. will be remembered by their students and colleagues alike.

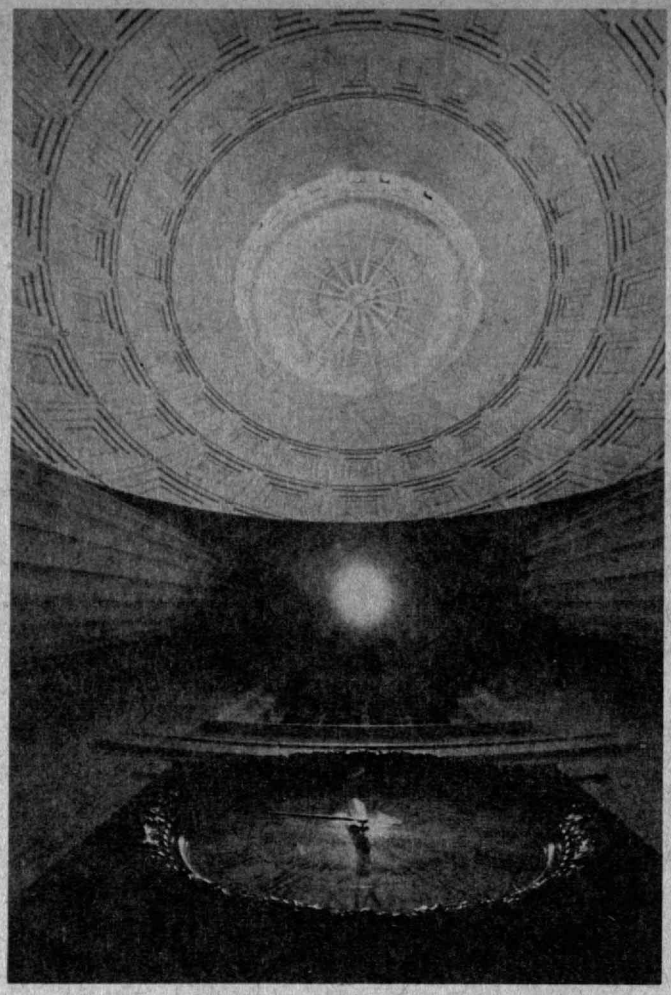
Of particular sadness to us during the year were the untimely deaths of three active and beloved members of the faculty. Lan Jen Chu, Webster Professor of Electrical Engineering, died after a brief illness in July, 1973. We honor him as a pioneer in the understanding of theoretical radiation problems and as a teacher who left an indelible impression on all those who had the privilege to be his students.

Arthur T. Ippen, Institute Professor Emeritus, died suddenly in April, 1974. A scholar of worldwide renown, Professor Ippen had been associated with M.I.T. for 29 years, and was personally responsible for developing a leading center of education and research in the field of water resources and environmental engineering related to water problems.

Samuel J. Mason, Cecil H. Green Professor of Electrical Engineering, died suddenly in March, 1974. He had come to M.I.T. in 1942, joining the Radiation Laboratory to work on microwave systems. Throughout his career at M.I.T., he was respected widely both for his scholarly attainments and for his deep-seated interest in young people.

These men have been outstanding examples of strength and dedication to our educational programs; they will be remembered and honored long by generations of their students, friends, and associates.

Jerome B. Wiesner, *President*
Paul E. Gray, *Chancellor*



Interior of the Great Dome.

PATTERNS OF GROWTH AND CHANGE 1940 to 1973

During the summer and fall of 1973, several of us tried to explore whether the ways in which the Institute had evolved during the past third of a century could help us to understand in a more than superficial manner how it might change in the quarter-century ahead of us. To make meaningful predictions obviously was difficult; during the time under consideration, the problems of our society, the conditions of science and technology, the structure of human knowledge, and humanity's expectations all have undergone profound changes. The widespread belief in progress which had accompanied the end of World War II seemed at times to have been replaced by a quasi-apocalyptic feeling that things were out of control, and that the improvident use of technology had been a major contributor to unhealthy growth and waste. We at the Institute were neither immune nor insensitive to these perturbations in the intellectual climate. The Institute's traditional Rogerian philosophy was a strong foundation on which to build, when many curricula elsewhere were blown away by the single word *relevance*. We tried to deepen our understanding—and that of M.I.T. students—of the nation's and of humanity's problems, in the firm conviction that more science and technology would lead to wiser management through responsible use of the opportunities which both basic and applied research provide.

Since 1940, M.I.T. obviously has both grown and changed. Some of the dimensions of this growth are fairly easy to document and even to quantify; however, most of the patterns of change, of increased complexity, are much harder to grasp, let alone to describe numerically.

Let us begin with the number of students attending M.I.T., which has increased by a factor of 2.5 between 1940 and 1973; among the total of students, undergraduates have barely doubled, while the graduate population has increased by a factor of five. We have no figures for the postdoctoral student population before World War II; today there are approximately 500 "postdocs" on campus. The percentage of women students has increased significantly, especially since the opening of McCormick Hall in 1963.

STUDENT ENROLLMENT

Including special students

	1940	1950	1960	1970	1973
Total Students	3,100	5,458	6,270	8,024	7,850
Undergraduate	2,379	3,856	3,580	4,074	4,183
Percentage of Women	1%	1%	2%	6%	11%
Graduate	721	1,602	2,690	3,950	3,667
Percentage of Women	3%	2%	3%	8%	10%

If we look for more meaningful detail in the growth of the student body by examining the distribution of undergraduate and graduate students by Schools, we find the following. The combined percentage of the Schools of Engineering and Science has hardly changed (from 81 to 76 percent), but the mix between the two has; in 1940, the ratio of undergraduate engineering majors to science majors was 3:1, while in 1973 it was 1:1. However, in absolute numbers there were approximately 1,100 engineering majors in 1940, and approximately 1,200 in 1973. It would be informative, of course, to examine intra-School trends and shifts more closely, and to study (for instance) the relative stability of enrollment in the Department of Electrical Engineering compared to the dramatic increase in biology majors within the last decade. (This increase was preceded by the rise of molecular biology and by a career shift toward the health professions—for example, roughly 10 percent of the Class of 1974 entered medical school, compared with 1 percent of the Class of 1940.)

UNDERGRADUATE ENROLLMENT—by School

Freshmen excluded: special students included

	1940	1950	1960	1970	1973
Total Undergraduates (freshmen excluded)	1,774	3,112	2,644	3,107	3,137
Engineering	61%	65%	56%	40%	38%
Science	20%	18%	28%	31%	38%
Management	11%	11%	8%	4%	4%
Humanities and Social Science	—	2%	4%	11%	6%
Architecture and Planning	4%	4%	4%	5%	6%
Undesignated	4%	—	—	9%	8%

The number of graduate students has increased almost fourfold in the School of Engineering, and by slightly more than fourfold in the School of Science. However, the combined percentage of these two Schools drops from 94 to 74 percent. We see substantial increases in the graduate student population of the three smaller Schools: the Sloan School of Management, the School of Humanities and Social Science (where only programs in the social sciences have graduate students), and the School of Architecture and Planning. Two of these Schools came into existence in the immediate postwar period (Humanities in 1950, and Sloan in 1951).

GRADUATE ENROLLMENT—by School

Excluding special students

	1940	1950	1960	1970	1973
Total Graduate Students	689	1,450	2,258	3,395	3,328
Engineering	427	889	1,257	1,555	1,522
(percentage)	62%	61%	56%	46%	46%
Science	222	444	669	1,046	938
(percentage)	32%	31%	30%	31%	28%
Management	19	32	164	329	360
(percentage)	3%	2%	7%	10%	11%
Humanities and Social Science	—	43	103	282	274
(percentage)	—	3%	4%	8%	8%
Architecture and Planning	21	42	65	183	234
(percentage)	3%	3%	3%	5%	7%

Given the above figures, the table reflecting degrees granted should present little surprise. The total number of degrees granted annually has almost tripled; today there are roughly as many *master's and engineer's* degrees as there are *bachelor's*. The number of doctorates is 6 to 7 times what it was in 1940, when the Graduate School was just a few years old.

DEGREES GRANTED

	1940	1950	1960	1970	1973
Bachelor's	509	1,052	824	873	1,038
Master's and Engineer's	301	504	781	874	945
Doctorates	64	166	199	439	396
Total	874	1,722	1,804	2,186	2,379

The next table summarizes quite a few economic data: tuition, student costs, and beginning salary. Though each of these quantities approximately triples during the time interval considered, the ratios of tuition to salary (and budget to salary) remain amazingly stable. Without entering into the kind of detail which would be necessary to understand the complex nature of student aid, let us mention just two figures: undergraduate student aid climbed from $200,000 in 1940 to roughly $5 million in 1973!

FOUR-YEAR TUITION AND STUDENT COSTS AS RATIOS OF S.B. STARTING SALARY

	1951	1960	1970	1973
Four-Year Tuition	$3,100	$ 4,800	$ 8,100	$10,200
Four-Year Student Budget	6,825	10,050	15,400	18,800
Median Annual Starting Salary Offer (S.B.)	3,804	6,432	10,500	11,280
Tuition/Salary*	.815	.745	.771	.904
Budget/Salary**	1.76	1.565	1.47	1.67

*Ratio of four-year M.I.T. undergraduate *tuition* costs upon graduation to graduate's median starting annual salary.
**Ratio of four-year M.I.T. undergraduate student *budget* costs upon graduation to graduate's median starting annual salary.

The expansion of the student body and the related expansion in research[1] have been accompanied by an increase in the number of employees, which is depicted in the following table. Here the category of *teaching staff* includes faculty, instructors, and teaching assistants, while the category of *research staff* currently includes approximately 1,000 graduate students who are research assistants, as well as postdoctoral fellows, staff members of sponsored research projects, and so forth.

ON-CAMPUS EMPLOYEES—by function

Lincoln and Draper Laboratories excluded

	1940	1950	1961	1970	1973
Teaching Staff	538	865	1,187	1,727	1,703
Nonfaculty Research Staff	185	940	1,177	2,213	2,467
Administrative Staff	75	114	249	533	582
Library, Medical, and M.I.T. Press Staff	9	38	69	135	155
Support Staff	583	1,695	2,029	3,090	2,891
Total	1,390	3,652	4,711	7,698	7,788

[1]All research projects and programs are directed by members of the faculty, and practically all research involves graduate students; many research projects include the active participation of undergraduates, especially since U.R.O.P.—the Undergraduate Research Opportunities Program—came into being.

If we focus on faculty members only, we see that the total number has increased a little more than threefold since 1940. The tenured faculty has increased continuously in number, but in the period of greatest faculty expansion—the late fifties and early sixties—the percentage of tenured faculty decreased, when most of the new faculty members were brought in as assistant professors. In recent years, many of these assistant professors have been promoted to higher rank and tenure, while the overall number of faculty members has stopped growing. Thus during the last five years, the faculty size has remained essentially constant, while the age and rank distribution have been changing. During this period, the number of assistant professors has decreased by about 60.

TENURED FACULTY

Excludes visiting faculty, emeriti faculty
Includes administrative, faculty on leave, medical, and athletic faculty

	1940	1946	1950	1955	1960	1965	1970	1973
Number Faculty	274	315	425	498	621	793	881	881
Number Tenured	NA	192	255	279	298	365	475	525
Percent Tenured	—	61%	60%	56%	48%	46%	54%	60%

The next table shows the sources of funds and revenues for all M.I.T. operations (including the Lincoln and Draper Laboratories) for the period 1940–1973. All of the component sources increased substantially (in part because of inflation), but none as much as the funds for sponsored research. These funds include overhead allowances, which increased from roughly $3 million in 1950 to over $30 million in 1973.

SOURCES OF FUNDS AND REVENUES FOR OPERATIONS

(In millions of dollars)

	1940	1950	1960	1970	1973
Tuition and Fees	$1.8	$4.2	$7.9	$18.5	$24.6
Investment	1.2	1.3	2.2	7.3	9.8
Gifts	0.1	2.1	6.1	9.1	8.4
Auxiliaries*	0.4	1.4	1.9	6.9	7.9
Sponsored Research**	0.2	12.0	65.4	169.9	218.1
(including on-campus)	(0.2)	(9.2)	(20.1)	(56.5)	(71.8)
Unrestricted Funds Used for Operating Expenses	—	0.1	—	4.6	0.8
Total	$3.7	$21.1	$83.5	$216.3	$269.6

*Housing, Dining, M.I.T. Press
**Does not include the Use of Facilities Allowance

During the period 1950–1973, the mix of governmental and private agency contribution to the funds for on-campus sponsored research (i.e. excluding the Lincoln and Draper Laboratories) changed appreciably, as the following table indicates. This table contains a good deal of information, perhaps as much about how in the last 25 years Federal agencies have divided among themselves the support for academic research as about the growth of research in the life and health sciences to a point where it comprises roughly one-third of all research done at M.I.T. Three further comments are in order: 1) the passing of the Mansfield Act accounts for the rather sudden shifts between Department of Defense and National Science Foundation support between 1970 and 1973; 2) the category labeled "industry" hardly conveys an accurate picture of the several ways (Industrial Liaison Program, annual gifts, and so forth) in which industry supports the Institute—furthermore, industry's percentage of support for sponsored research for the fiscal years 1974 and 1975 is substantially higher than for 1973; and 3) in recent years, the annual rise in total research support has not kept pace with inflation.

This is an appropriate point at which to put into brief perspective the change in Federal policy regarding graduate fellowships and traineeships. Throughout the late 1950s and the 1960s, the number of these fellowships increased. In fiscal years 1969 and 1970, M.I.T. graduate students held approximately 700 such Federal fellowships and traineeships. Since then, the number of awards to M.I.T. students has been cut in half, although M.I.T. students (and M.I.T. as an institution) are among the most successful competitors for the much smaller fellowship pie.

ON-CAMPUS SPONSORED RESEARCH—
SOURCES OF FUNDING

	1950	1960	1970	1973
Department of Defense	81%	47%	27%	18%
National Science Foundation	—	8	11	21
Atomic Energy Commission	12	21	15	11
National Aeronautics and Space Administration	1	2	11	11
National Institutes of Health*	—	6	15	18
Other Federal Government	2	2	5	6
Total Federal Government	96%	86%	84%	85%
Foundations, Education, and Other Nonprofit	—	4	11	10
Industry	4	6	3	3
Other**	—	4	2	2
Total	100%	100%	100%	100%
On-Campus Sponsored Research Revenues (in millions)	$9.2	$20.1	$56.5	$71.8

*Includes Public Health
**Approximately one-half state and local government and one-half Lincoln and Draper Laboratories

The growth in students, staff, and research support which we have documented obviously needed to be matched by an enlarged physical plant. The next table depicts the various components of this growth. The Support, Administration, and Services category includes such items as libraries, parking garages, and the chilled water plant. The expansion of residential space has made it possible to house 2,000 undergraduates in on-campus dormitories, in addition to the 1,200 who live in nearby fraternities. These figures, which reflect the outcome of the Second Century Fund drive, do not give us details on the age distribution of our buildings. M.I.T.'s physical plant has a book value of close to $200 million. At current building costs, we must maintain and renovate the plant to keep it efficient, since we cannot think of replacing it. However, maintenance and renovation also are costly, especially for buildings full of sophisticated equipment which requires air conditioning. The recent rise in the cost of utilities is common knowledge; what is perhaps less obvious is that the "intensity of use" (here defined as the number of kilowatt hours per square foot of academic space) has on the average quadrupled since 1940.

BUILDING AREA

(In millions of gross square feet)

	1940	1950	1960	1970	1974*
Academic	1.2	1.5	2.1	3.6	3.9
Academic Support, Administration, and Services	0.1	0.2	0.4	1.4	1.5
Subtotal	1.3	1.7	2.5	5.0	5.4
Athletic and Residential	0.5	0.9	1.0	1.5	2.0
Total	1.8	2.6	3.5	6.5	7.4

*Estimated – includes Center for Cancer Research and Electrical Engineering buildings

As we conclude this statistical bird's-eye view of the Institute's recent past, we must be aware of what we have not encompassed; any attempt to describe a complex institution suffers from a kind of Gresham's Law, in that the quantifiable drives out the significant. There is little in these data that captures the quality of distinctive excellence which the Institute has achieved in this third of a century, a level of excellence for which Drs. Compton, Killian, Stratton, and Johnson have laid the foundations. We could cite statistics on the number of faculty members who are members of academies, or who have won awards and prizes (including the Nobel prize); on the high ratings that departments and Schools obtain from their professional peers; and equally importantly, on the number of top students from the U.S. and other countries who choose M.I.T. over other universities; but all of these still might fail to convey the essence of the reputation which M.I.T. enjoys throughout the world.

We also have not addressed ourselves to the substantive evolution of disciplines and fields. $(\text{Physics})_{1940}$ clearly is different from $(\text{physics})_{1973}$,[2] and to be able to do first-rate physics in 1973 demands different facilities, resources, and talents from those required a third of a century ago. Some of these facilities, resources, and talents have been assembled in interdepartmental laboratories, a new institutional form that came into being after World War II. The Research Laboratory of Electronics, founded in 1946 (as the successor to the famed Radiation Laboratory of World War II), has been the forerunner of close to two dozen interdepartmental laboratories, centers, and programs. These range from space research to international studies, from nuclear science to the Sea Grant Program, from artificial intelligence to transportation, and from materials science and engineering to cancer research.

Many of these laboratories and centers have become incubators of new fields, while others represent problem or mission oriented units in which engineers, natural scientists, and sometimes social scientists collaborate across departmental boundaries. Outside agencies may find it easier to "resonate" with such units than with departments organized along strictly disciplinary lines. The fact that approximately one-half of the Institute's research support comes through these interdepartmental laboratories supports such an assumption.

Finally, we have not dealt with changes in educational patterns, which are at the core of the Institute's commitment. An earlier section of this Report deals with these very issues. What we present in this appendix, then, documents some but clearly not all of the patterns of growth and change which illuminate our institutional history, and which may help us to understand more fully the foundation on which we build our future.

Walter A. Rosenblith, *Provost*

[2]A fact that is underlined by the number of departments that have changed names during the period under consideration.

STATISTICS FOR THE YEAR

The following paragraphs report briefly on the various aspects of the Institute's activities and operations during 1973–74.

REGISTRATION

In 1973–74, student enrollment was 7,888, an increase of 38 over the 7,850 enrolled in 1972–73. This total was comprised of 4,113 undergraduate and 3,775 graduate students.

Graduate students who entered M.I.T. last year held degrees from 357 colleges and universities, 210 American and 147 foreign. The foreign student population was 1,429, representing 18 percent of the total enrolled. The foreign students were citizens of 93 different countries.

Degrees awarded by the Institute in 1973–74 included 1,065 bachelor's degrees, 832 master's degrees, 102 engineer's degrees, and 378 doctoral degrees—a total of 2,377.

The number of women at M.I.T., both graduate and undergraduate, has increased continuously. In 1973–74, 921 women students were at the Institute, compared with 816 in 1972–73. In September, 1973, 122 first-year women entered M.I.T. In 1973–74, 194 degrees were awarded to women.

STUDENT FINANCIAL AID

During 1973–74, the student financial aid program again was characterized by increases in total awards, in loans made, and in the amount of scholarship assistance. There was again a decrease in the number of individuals assisted.

A total of 1,671 undergraduates who demonstrated the need for assistance (42 percent of the enrollment) received $3,014,426 in scholarship aid and $1,884,323 in loans. The total of $4,898,749 represented a small increase in direct aid over last year.

Scholarship assistance was provided by the scholarship endowment in the amount of $1,746,194, by outside gifts for scholarships in the amount of $654,447, and by direct grants to needy students totaling $524,310. Scholarship assistance from M.I.T.'s own operating funds was not used during the year. The special program of scholarship aid to minority group students represented an additional $89,475 from specially designated funds. An additional 360 students received direct grants from outside agencies, irrespective of need, in the amount of $708,653. Outside scholarship support thus totaled $1,887,410, a substantial increase over last year's total. A significant portion of the increase was due to increased funding of the Federal government's grant-aid program. The undergraduate scholarship endowment was aided by the addition of $410,639 in new funds, which raised the principal of the endowment to $20,983,707.

Loans totaling $1,884,323 were made to needy undergraduates. Of this amount, $572,555 came from the Technology Loan Fund, $1,309,268 from the National Defense Loan Fund, and the remainder from other M.I.T. loan funds. An additional $377,269 was obtained by undergraduates from

FIGURE 1

FINANCIAL AID TO UNDERGRADUATE STUDENTS FROM ALL SOURCES, 1964-1974

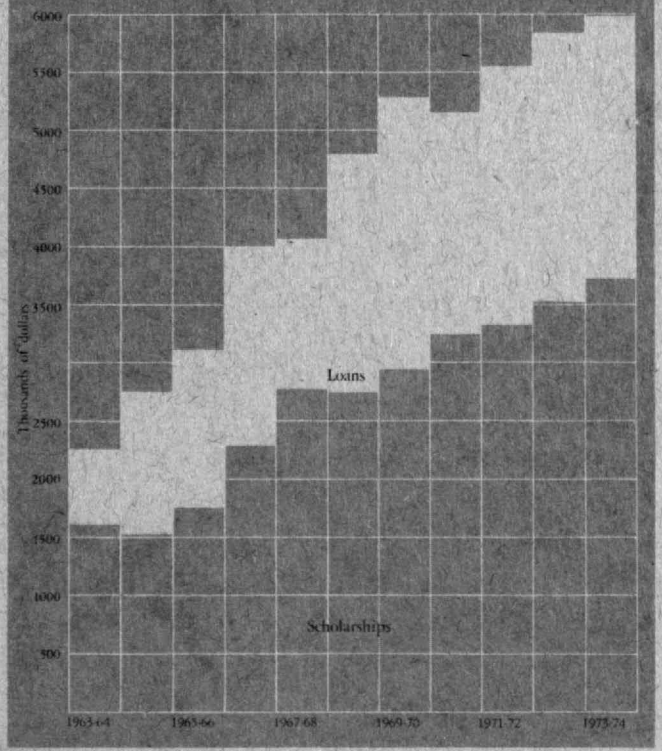
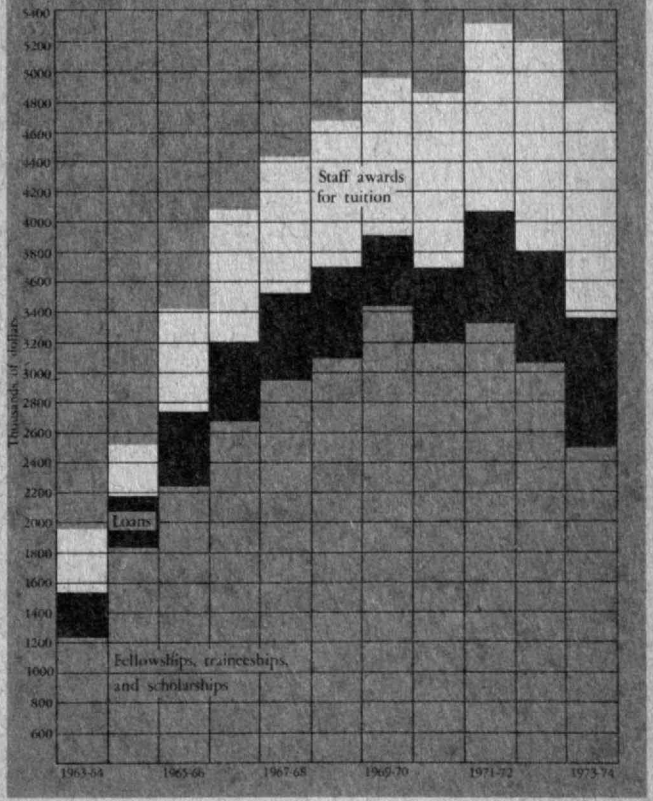


FIGURE 2

FINANCIAL AID TO GRADUATE STUDENTS AWARDED BY M.I.T. 1964-1974



state administered Guaranteed Loan Programs and other outside sources.

Graduate students obtained $852,010 from the Technology Loan Fund. Of this total, $331,730 was loaned under the Guaranteed Loan Program and qualified for Federal interest subsidies and guarantees. The total loaned by M.I.T. to both graduate and undergraduate students was $2,736,333, an increase of $103,117 over last year's total.

CAREER PLANNING AND PLACEMENT

The past year saw a continued upswing in the demand for M.I.T. graduates in most fields of study. More companies and government agencies came in search of engineers and scientists than in any of the previous three years. Mindful that national enrollments in engineering have decreased sharply, many employers made an extra effort to attract their share of candidates. The demand for master's degree candidates in management remained strong, but it was less than the demand for engineers. The number of employers recruiting at the Sloan School of Management dropped slightly, and salary offers increased hardly at all. In contrast, the employment outlook in architecture was grim indeed. On the last day of classes in May, 1974, no one on the graduate degree list in this area had found a job. By the end of June, a few students had better things to report, but a large number still were unemployed.

Starting salaries moved upward in keeping with the market, although not as steeply as the consumer price index. Graduating students joined that large section of the population which has suffered from the prevailing inflation more than it has contributed to it.

An important event during the year was the move of the Career Planning and Placement Office from the fourth floor of the Ford Building to new quarters on the first floor of Building 10. As a result, the number of students using the Office has increased considerably, perhaps as much as 30 percent. Activity also increased in the area of alumni placement. The number of alumni registering with the Office rose to over 500, from 403 the previous year. In January, 1974, the Office began publication of a four-page job listing (the M.I.T. Alumni Placement *Gazette*) which is sent approximately once every two weeks to all alumni who maintain current registration. Each issue describes 25 to 30 of the most attractive jobs reported to the Office since the previous issue went to press. The *Gazette* has been received very well by alumni.

FINANCES

As reported by the Treasurer, the total financial operations of the Institute, including sponsored research, decreased from the level of 1972–73. Educational and general expenses—excluding the direct expenses of departmental and interdepartmental research, the Lincoln Laboratory, and the Charles Stark Draper Laboratory—amounted to $82,432,000 during 1973–74, compared to $75,297,000 in 1972–73. Reflected in the finances of the Institute was the increase in the use in operations of unrestricted funds to $2,528,000, compared with $757,000 in the preceding year. In addition, the Research Reserve was drawn on for the first time, in the amount of $2,781,000.

The direct expenses of general departmental and interdepartmental sponsored research increased from $58,704,000 to $59,436,000, and the direct expenses of major laboratories and special departmental research decreased from $129,613,000 to $76,989,000, largely as a result of the Draper Laboratory divestment.

The construction program of the Institute continued to make progress in 1973–74, with the book value of educational plant facilities increasing from $182,063,000 to $190,029,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, had a book value of $340,866,000 and a market value of $388,176,000. This compares to book and market totals of $339,333,000 and $440,924,000 last year.

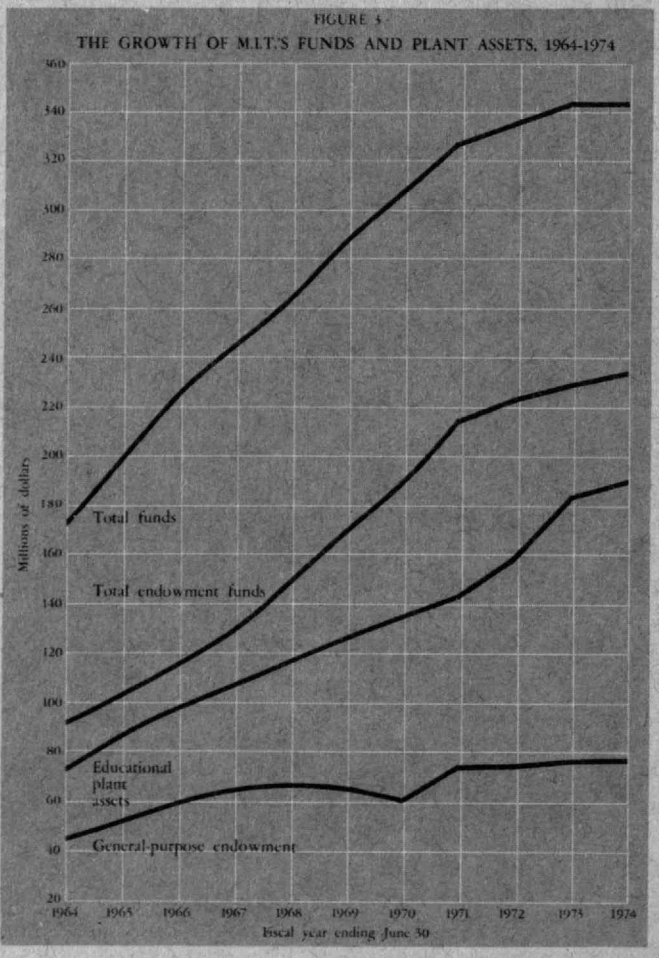
GIFTS

Gifts, grants, and bequests to M.I.T. from private donors increased from $21,664,000 in fiscal year 1972–73 to $22,666,000 in fiscal year 1973–74. The latter figure includes unrestricted direct gifts to the Alumni Fund of $864,000, which constituted part of the total of $2,917,000 reported by the Alumni Fund in 1973–74.

PHYSICAL PLANT AND CAMPUS ENVIRONMENT

Construction continued during the year on two academic and research projects—the Chemical Engineering Building, which is located to the east of the Whitaker Building, and the

FIGURE 5
THE GROWTH OF M.I.T.'S FUNDS AND PLANT ASSETS, 1964-1974



Seeley G. Mudd Building adjacent to the Ford Building. In the spring of 1974, the two basement foundations of the Chemical Engineering Building were completed; work has begun on the building's superstructure.

The fifth floor of the Seeley G. Mudd Building was completed in December, 1973, just nine months after the start of construction. The staff of the Center for Cancer Research moved into that floor immediately and initiated their research programs, while construction continued on the remaining floors. The Arteriosclerosis Center, located on the fourth floor, was completed and occupied in May, 1974, and the headquarters of the Center for Cancer Research on the first floor were completed in June. The remainder of this building was substantially complete by the summer of 1974.

Major construction was initiated during the year on the West Campus Undergraduate House and the Geophysical Underground Laboratory. The West Campus Undergraduate House, a reinforced concrete residence for 300 students, will be located on Memorial Drive adjacent to MacGregor House. Foundation work on this structure was begun in April, 1974; the building is scheduled to be occupied in the fall of 1975. The Geophysical Laboratory, located near the Wallace Astrophysical Observatory in Westford, Massachusetts, will be devoted to seismic research.

In the housing area, the renovation of the west wing of Ashdown House was completed in November, 1973; students moved into the new spaces in December. Renovations began immediately on the east wing of the building, and this work is now substantially complete.

Two other projects involving changes in dormitory spaces were completed this year. Since an office and desk area were built on the first floor of its Ware entryway, Senior House has functioned independently of the East Campus Houses. Also, the west lounge on the fourth floor of Baker House underwent a renovation which incorporated new furnishings, lighting, and carpeting.

On May 30, 1974, the Institute received a Special Award of Merit from the Massachusetts Horticultural Society "for the use of trees and plants around a great university." One of only five such awards made for the year 1973 by this prestigious horticultural organization, the merit award was the first such honor presented to an entire university campus.

The Julie Fassett Memorial Garden.

Institute Review

The Department of Mechanical Engineering has had 11 Heads in its 109-year history, and seven of them are still living. Here they are gathered together on the staircase in Endicott House at a special celebration during the fall: (front to back) Jerome C. Hunsaker, '12 (1933-47), C. Richard Soderberg, '20 (1947-54), Jacob P. Den Hartog (1954-58), Joseph H. Keenan, '22 (1958-61), H. Guyford Stever (1961-65), Ascher H. Shapiro, '38 (1965-74), and Herbert H. Richardson, '53 (1974-). Last year the American Council on Education judged the Department to have the best graduate program and most effective faculty among all those in U.S. colleges and universities. (Photo: Calvin Campbell)

In This Section

The Alumni Officers Return

On the 100th anniversary of the Alumni Association, Donald P. Severance, '38, speaks for its 40,000 members: "I am happier today because I have been able to be a part of M.I.T." (**page 102**) . . . Constantine B. Simonides, Vice President, finds that a "positive disposition" characterizes alumni attitudes toward the Institute (**page 102**) and promises a full report of alumni survey findings early in 1975 . . . Why? Because, says Howard W. Johnson (**page 104**), M.I.T. "is an idea that captures the imagination of people who have been close to it."

Other News and Views

The Treasurer finds M.I.T.'s funds "well maintained" in a financially difficult year (**page 105**) . . . The School of Engineering tells high school teachers that social and cultural as well as scientific and engineering issues can be part of a single undergraduate education (**page 106**) . . . A month-long strike of custodians and cooks (**page 107**) . . . A new cabin for the Outing Club (**page 108**) . . . Gold medals for the crew (**page 109**).

People and Places

Three new professorships in the Sloan School . . . new leadership for the Department of Humanities, the Center for Advanced Visual Studies, and the Center for Advanced Engineering Studies . . . a new Faculty Resident finds "it's nice to have lots of people around" (**starting on page 111**).

Changes and Constants for the Second Century

Just 100 years ago next January 29, Professor Robert H. Richards, Class of 1868, became the first President of the Alumni Association of the M.I.T., and shortly thereafter he wrote to President William Barton Rogers, with remarkable understatement: "The feeling seems to prevail that in many ways the Association may prove of real benefit to the school and its members."

Was it this impending anniversary which drew alumni back to M.I.T. in record numbers for the 1974 Alumni Officers Conference on September 13 and 14? No one seems to know. But 767 alumni and guests registered, 250 more than in any previous year; they came from every class from 1909 to 1974 and from 17 graduate departments, and from as far away as India and Argentina.

Howard W. Johnson, Chairman of the M.I.T. Corporation had an answer: "Because M.I.T. is essentially an idea that captures the imagination of people who have been close to it." That very thing has happened to him and his wife Betty; when he received the Bronze Beaver Award of the Alumni Association on Saturday, Mr. Johnson called the warmth of the "M.I.T. family" "the most remarkable thing in our lives."

James R. Killian, Jr.. '26, had a similar answer: "M.I.T. is an original," he said, "a unique college format" which we all want to maintain. This uniqueness rubs off on alumni, he said, who are in turn unique in their understanding and in their contributions—"a significant fraction of the leadership of this country," he said.

Alumni may tend to take these traditions for granted, thinks Donald P. Severance, '38, Executive Vice President of the Alumni Association, but pride of association extends to thousands of graduates—many of whom he has heard say, "I am happier today because I have been able to be a part of M.I.T."

The next century will be at once the same—and very different. During the first 100 years, said Luis A. Ferre, '24, President of the Alumni Association, M.I.T. and its graduates have been problem-solvers, "participating in the optimism of the technological revolution, believing that . . . the material goods of life . . . would bring us to a world of peace and understanding."

But now we know, said Mr. Ferre, "that simplistic solutions based on material abundance through technology are not enough." Our problem is to understand and then to respond to the full impact of our achievements, "to obtain the fullness of life which generates happiness" instead of being "enslaved by the ephemeral pleasures of consumption."

Whatever the future brings, some principles remain sacrosanct, taken almost for granted. One is the generous support of the Institute by its alumni: $2.917 million in gifts to the Alumni Fund from 20,909 alumni in 1973-74, according to Frederick G. Lehmann, '51, Director of the Alumni Fund. The goal for 1974-75 is $4 million, and fulfilling it is more essential now than any time in our history, said Mr. Ferre.

Every alumnus expects of M.I.T. that it will maintain its high standards of performance, adapting to change and serving public needs, said Mr. Severance. In particular, he said, two traditions of alumni relations are so deeply ingrained in the Institute's history that they tend to be taken for granted:

—Let the Institute and its alumni, when they come together, focus on serious business and on the real issues before them; "academic sideshows" are unnecessary.

—Let M.I.T. and the Association maintain the "fragile tradition of openness between campus and alumni. The capacity of both to expose themselves to criticism," said Mr. Severance, "is a foundation of M.I.T.'s alumni relations."□

A "Positive Disposition" by 75 Per Cent of M.I.T.'s Alumni; the Problem Now Is How to Build on It

Interest, loyalty, and a positive attitude toward M.I.T. characterize the response of the vast majority of alumni to the Institute.

The Institute's problem—if indeed it has one—in continuing to build bridges with its alumni is to respond to the diversity of their interests and so to capitalize upon the warmth and good will which already exist among 40,000 alumni throughout the U.S.

No easy problem, thinks Constantine B. Simonides, Vice President of M.I.T., who devoted much of his spring and summer to directing an intensive telephone survey of alumni attitudes toward the Institute.

There were more than 700 open-ended telephone interviews with a cross-section of alumni representing all ages, all geographical regions, all departments, and all degrees in roughly the proportions they are found in the total alumni body. Using an interview guide designed to elicit spontaneous views of alumni rather than a traditional questionnaire, the interviewers sought to trigger alumni responses on all levels and aspects of Institute affairs. The interviews—"structured conversations," Mr. Simonides called them—averaged an astonishing 53 minutes and resulted in 13,000 pages of interviewers' notes. The process of analyzing these responses is far from complete, and a full report is due early in 1975.

But by early September, Mr. Simonides was able to tell alumni attending the annual Alumni Officers Conference that some three-quarters of all those interviewed could be characterized as having "positive" views of the Institute; about three-fifths expressed positive interest, and one out of seven could be described as interested, knowledgeable, and to some degree involved.

"If there is a 'positive disposition' from 75 per cent and a real interest in the Institute among 60 per cent of the alumni," Mr. Simonides told his A.O.C. audience, "there is plenty of room for building an even more dynamic partnership between M.I.T. and its alumni." One alumnus, typical of many, said, "I really would like to feel closer to M.I.T."

Diversity, Pluralism, and One Consensus

But beyond this consensus of positive inclination and interest lies great diversity. "Pluralism" was the key word in Mr. Simonides' report.

"This pluralistic approach, and the ways to achieve it, are the keys to the agenda suggested to us by the survey," Mr. Simonides told his A.O.C. audience. Approaching this problem, he said, he takes comfort from what appeared to be "solid confidence in the value and credibility of an M.I.T. education—and no small measure of pride" on the part of alumni. One alumnus even reported that "when people find out you're from M.I.T. they feel you should know everything. . . . Very disturbing!"

"M.I.T. alumni are first of all individuals," Mr. Simonides said. "It has become clear to us that if we are to build a composite picture of M.I.T. alumni it will have to look more like a constellation than a single ray of light."

But some of the individual remarks had "laser-like sharpness."

"If I were of college age today, I'd just grit my teeth and do it again," said one alumnus. Indeed, about 70 per cent of those interviewed said they would probably come to M.I.T. again.

There were many "very positive and often superlative comments about the reputation of M.I.T.," Mr. Simonides said. The reputation of M.I.T.'s faculty and the quality of its research and academic programs were frequently mentioned. On the other hand, about one-quarter of the alumni volunteered comments on the quality of teaching and on the faculty's interest in students, and about two-thirds of these comments were negative.

Bridges between M.I.T. and its alumni were the constant theme of the 1974 Alumni Officers' Conference in September—in program and in practice. The top picture directly above shows Howard W. Johnson, Chairman of the Corporation, conferring with Max Seltzer, '18 (right), Chairman of the Conference; at the bottom, right, Donald P. Severance, '38, receives from William S. Edgerly, '49, (right), former President of the Association, the coveted Bronze Beaver Award while Luis A. Ferre, '26 (left), awaits his turn at the podium. The remaining pictures recall the bridges forged during 24 hours of intensive discussion.

Reaching Out and Building Bridges

In discussion groups following Mr. Simonides' report, alumni officers began the task—it will continue and intensify in future months—of translating survey results into new activities and programs for alumni relations with M.I.T.

There was repeated emphasis on professional relations—more association between alumni and their departments, more feedback from alumni to help keep M.I.T. teaching current with industrial problems, more "continuing education" for alumni, greater emphasis on departmental in addition to class affiliations.

And improved communications between Institute and alumni—and among

alumni—came in for considerable discussion—through existing (*Technology Review*, Alumni Advisory Council, club programs) and new (departmental bulletins, regional professional conferences) channels. No one could argue with Mr. Simonides' conclusion that alumni "need and want the clearest possible picture of M.I.T.," nor with his resolve to "reach out to them in pluralistic ways" which will respond to their many different interests and motivations.□

Building on 100 Years of Support and Loyalty

If Constantine B. Simonides' results (*see above*) tell him anything about M.I.T and its alumni, it is that "the great Institute-alumni relationship" on which M.I.T.'s strength has been built during the 100 years, since the founding of the Alumni Association, "will continue to thrive and grow in the new century ahead," Howard W. Johnson, Chairman of the Corporation, said at the opening session of the Alumni Officers Conference this fall.

Mr. Johnson had some figures of his own from the study of alumni attitudes:

—Alumni have "very strong, positive feelings about the quality and character of the Institute." Two-thirds of the random sample, said Mr. Johnson, "volunteered very favorable or even superlative comments about M.I.T.'s general standing and reputation."

—Two-thirds of the alumni queried said that the fact that they studied at M.I.T. had been "very important" to them. One respondent, said Mr. Johnson, told the interviewer, "I owe my life—socially, economically, and intellectually—to M.I.T."

—Asked to comment on the role of private education in the U.S., said Mr. Johnson, "there were 14 alumni who said that they supported private education for each one that did not."

—Asked about M.I.T.'s financial situation, half of the alumni judged the Institute had "some problem," said Mr. Johnson. "One out of six thought we have a serious problem, while an equal number felt that M.I.T. is better off than most institutions. Both these views are true," he added.

Why are alumni so loyal, helpful, and supportive?

Mr. Johnson's answer: "Because M.I.T. is essentially an idea that captures the imagination of people who have been close to it. Scientific discovery, learning, and advancement, along with the development of a skill to act, to think, and to learn—all coupled with the concern for the greater advance of humankind—is a compelling and perhaps a unique collection of educational ideas." □

Nine Beavers to Honor "Support . . . Devotion . . . Loyalty . . . Affection . . . Leadership"

Nine Bronze Beavers—the highest accolade for "distinguished service" to the M.I.T. Alumni Association—are now in the hands of proud new recipients, the result of presentations during the 1974 Alumni Officers' Conference. (There was no formal "awards luncheon," since a strike of custodial and food workers—*see p. 107*—closed campus kitchens and led to box lunches for A.O.C. visitors and an after-lunch awards session in Kresge Auditorium.)

The new Bronze Beaver winners are:

—**Claude W. Brenner**, '47, of Laser Graphic Systems, Sudbury, Mass., for "thoughtful, energetic, and consistent support of the Institute since his undergraduate days."

—**Paul M. Cook**, '47, President of Raychem Corp., Menlo Park, Calif., for "invaluable contributions to many facets of the Association and the Institute through local, regional, and national activities."

—**Harold E. Edgerton**, Sc.D.'31, Institute Professor Emeritus (electrical engineering) at M.I.T., whose "abiding interest in alumni and willingness to share his experience and knowledge have earned our esteem and deepest affection."

—**Howard W. Johnson**, Chairman of the M.I.T. Corporation, for "leadership and wisdom (which) contributed greatly to the Institute's forward thrust during times of rapid change and national stress."

—**I. Austin Kelly, III**, '26, former President of the National Employee Relations Institute, Inc., for "a long and distinguished record of service . . . exemplified by his leadership in class, club, and Fund activities."

—**George B. Morgan**, '20, former President of Standard Appliance Co., Beaumont, Texas, whose "many years of devoted service . . . exemplify the highest qualities of local leadership" and have made him "Mr. M.I.T. of Beaumont."

—**Donald P. Severance**, '38, Executive Vice President of the M.I.T. Alumni Association, for "an exemplary record of distinguished service . . . with tireless devotion and firm commitment to (M.I.T.'s) ideals . . . and imagination, vigor, and wisdom . . . for more than a third of a century."

—**L. G. Lee Thomas**, '20, former President of Thomas and Co., Philadelphia, whose "commitment and dependability have accented his outstanding service to the Institute in local, regional, and national activities . . . for more than five decades."

—**Karl R. Van Tassel**, '25, former President of A. B. Dick Co., who has "enriched" extensive activities in support of the Institute and Association "by his dedication and by his keen intellectual interest in science, technology, and management."

Two Presidential Citations were also given by Luis A. Ferre, '24, President of the Association, during the ceremonies:

—**The Central New Jersey Educational Council**, for "effort and enthusiasm above and beyond the call of duty, (fulfilling) with wisdom and energy the functions of the Educational Council in advising students, promoting school contacts, and developing closer ties between students (and alumni)."

—**The Chicago Committee for the Conference on "Management Amid Scarcity"** (John W. Barriger IV, '49, Chairman),

Proud winners of the Bronze Beaver pose with their trophies following the award ceremony in Kresge Auditorium during the 1974 Alumni Officers Conference: (left to right) Claude W. Brenner, '47, Harold E. Edgerton, Sc.D.'31, Karl R. Van Tassell, '25, George B. Morgan, '20, I. Austin Kelly III, '26, and Howard W. Johnson. The award to Donald P. Severance, '38, was made at the opening dinner (see p. 103).

whose "months of untiring endeavor and inspired planning" led to "a program of unequaled quality and value" which "will long serve as a standard of excellence" *(see October/November, p. 94).*

Mr. Ferre also reported two resolutions of appreciation adopted by the Board of Directors of the Alumni Association:

—The 1974 Alumni Day Committee, "for their dedication and imagination in creating an alumni weekend which stands out for its diversity and thoughtfulness."

—William S. Edgerly, '49, Financial Vice President of Cabot Corp., "for his dedicated leadership . . . and unremitting efforts to enhance and strengthen Institute-alumni relationships . . . as 79th President of the Association." □

Operations Down, Funds Maintained, and New Funds "a Major Goal"

M.I.T.'s total operations for 1973-74 were $223.8 million, down from $269.6 million in 1972-73. There were modest increases in departmental teaching and research and in sponsored research and a modest decrease in Lincoln Laboratory operations; the big difference was due to divestment of the Charles Stark Draper Laboratory.

To meet 1973-74 expenses, M.I.T. used the full amount of its new 1973-74 unrestricted resources—$3.17 million—and, as well, some $2.68 million of funds accumulated in earlier years.

In their annual report to the Corporation, President Jerome B. Wiesner and Chancellor Paul E. Gray, '54, called 1973-74, in financial terms, "a difficult year. The relentless pressure of inflation on the cost of operations increased dramatically, and our planned efforts at cost control proved insufficient to preserve the delicate balance that has held for the past several years," they wrote.

But by June 30, 1974, the book value of the Institute's invested funds was $340.8 million, higher by over $1.5 million than a year earlier and in fact higher than ever before in the Institute's history. Thus Stuart H. Cowen, Vice President for Financial Operations, and Joseph J. Snyder, '44, Treasurer of the Institute, told the annual meeting of the Corporation on October 4 that the invested funds of the Institute had been "well maintained" during the year despite "substantial" use of funds accumulated in earlier years to meet current operations.

They also agreed that "building the capital of the funds is a major financial goal for the Institute."

Book Value Up, Market Value Down

The market value of M.I.T.'s invested funds declined from $440.9 million on June 30, 1973, to $388.2 million a year later, a drop of $52.7 million. But investment income was higher in 1973-74—$19.4 million compared to $18.3 million the previous year.

The general investment portfolio was 50 per cent in equities, 38 per cent in fixed-income securities, and 12 per cent in real estate at the end of the 1973-74 year. A year earlier the comparable figures had been 53, 36, and 11 per cent.

Meantime, the market value of M.I.T. retirement plan investments—not part of the financial assets of the Institute—continued to slip below the book value: On June 30, 1974, the book value was $178.4 million, the market value $158.4 million; a year earlier the figures had been $156.2 and $155.7 million, respectively.

A "Steep Rise" in Energy Costs

A total of $5.8 million of current unrestricted resources and prior years' accumulated funds was needed in 1973-74. Of current unrestricted funds, over $2.5 million was allocated to operating expenses; the balance of $3.3 million from current and prior years' funds was devoted to meeting special, nonrecurring charges, principal among them operating losses and a write-down of M.I.T. Press receivables and inventories of $1.26 million, and provisions for underrecovery of costs on three housing projects for the elderly, undertaken on a "turnkey" basis for the Cambridge Housing Authority, of $539,000.

The 1973-74 unrestricted income came from three principal sources: gifts and bequests ($1 million), patents ($900,000), and allowances for the use of facilities for sponsored research ($1.2 million).

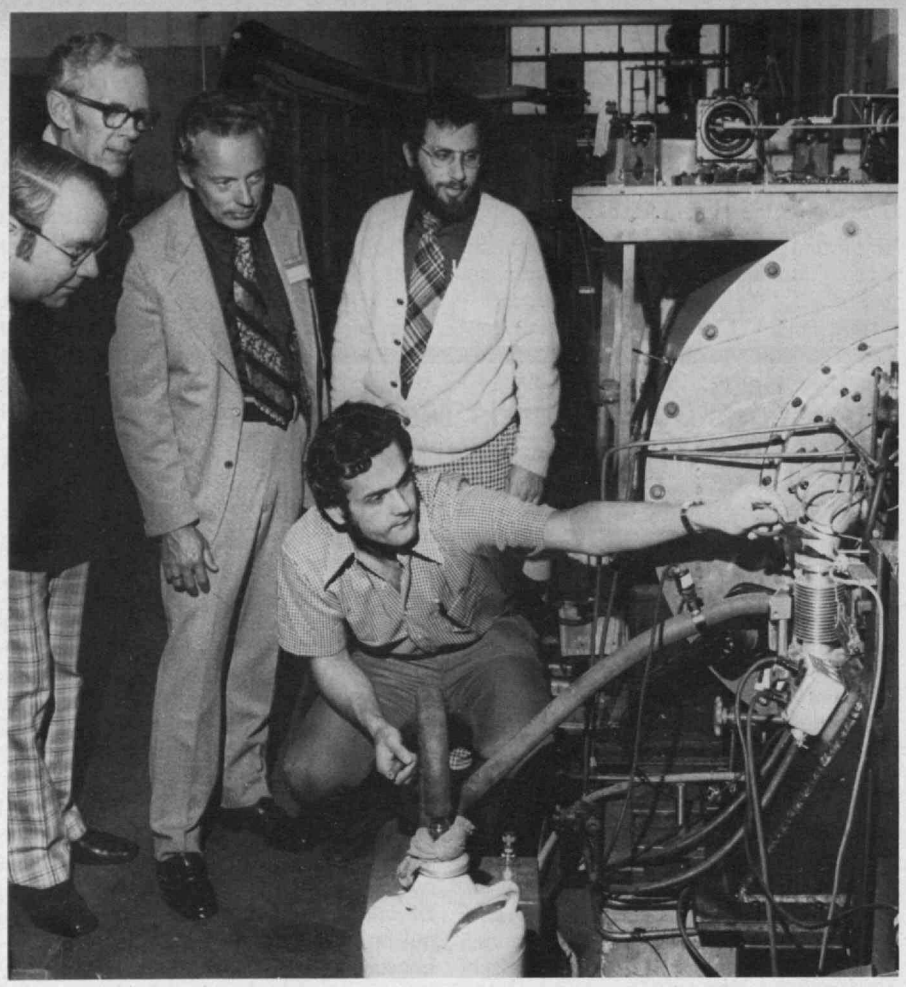
Gifts, grants, and bequests to M.I.T. were $22.7 million in 1973-74, up $1 million from 1972-73.

The largest single increase in operating expenses during 1973-74—nearly $1 million—was in plant operation and maintenance, reflecting in part "the steep rise" in the costs of fuel and electricity and in part the cost of operating and maintaining new additions to the Institute's physical plant.

The cost of utilities for the year exceeded the original budget by some $900,000, or 27 per cent; the unit cost of electricity nearly doubled and the unit cost of oil tripled during the year. President Wiesner and Chancellor Gray cited "heroic efforts at energy conservation throughout the Institute"; without them, the utilities budget would have been overdrawn by some $1.7 million.

The book value of educational buildings increased from $182 to $190 million during 1973-74, the increments being due to completion of the Sherman Fairchild (electrical engineering and electronics) and Seeley G. Mudd (cancer research) Buildings, modernization of Ashdown House, and construction on new undergraduate housing and the chemical engineering building.□

Engineering Is How Society Really Works



What is engineering really like? And M.I.T.? High school teachers don't know the answers to these questions well enough, think Alfred A. H. Keil, Dean of the School of Engineering, and Peter H. Richardson, '48, Director of Admissions. So they invited 100 science teachers to see for themselves during three days at the Institute in the fall—listening to faculty, visiting with students, and inspecting laboratories. Here they are learning about the Electric Power Systems Engineering Laboratory study of generators with superconducting field windings.

Engineering has always been a measure of history, connected to and molded by human needs as few other disciplines are. It is "the process by which resources are related to the real needs of people," J. Herbert Hollomon, '40, Director of the Center for Policy Alternatives in the M.I.T. School of Engineering, told more than 100 high school science and mathematics teachers at M.I.T. this fall—the art of "translating what is possible into what's do-able."

That definition of the engineer's role is as true today as in George Washington's time, despite vast and rapid changes in resources, needs, and spirit in the U.S. Now engineers' work is concerned with an environment so complex that only a systems understanding can assure its effectiveness. And the value of technology is now measured in social as well as economic terms, so an engineer must understand the state of society—art, law, even emotion—and must "be prepared to deal with cognitive styles which are not his own," said Dr. Hollomon.

"We maintain that it is possible to have one education based on technology that illuminates social and cultural as well as scientific and engineering issues—that shows how the society really works," he said.

How such an education really works was the subject of two days of discussions, demonstrations, and tours for the 100 high school teachers whose visit was sponsored by the School of Engineering. The idea, said Frank E. Perkins, '55, Assistant to the Dean of Engineering, was to have "a dialogue between those of us in the 'ivory tower' and you who are responsible for the students who come to us. We want better contacts with high schools," he said, "a better information flow in both directions."

Alfred A. H. Keil, Dean of the School of Engineering, hoped the result might be to make the best high school students in America "aware and excited" by the opportunities of modern technology—a field whose current image is blurred, out of focus, even wrong. He hopes that high school teachers can show more of them "the challenge and beauty of physics and mathematics—and their usefulness through engineering."

How to Start with a Blank Paper

The high school teachers discovered quickly that much of an M.I.T. engineering education consists of simultaneously doing *and* learning. The first class in engineering design consists of a problem: given wooden coffee stirrers, pipe cleaners, paper, and cork, build the strongest possible bridge. Mixed results, said Professor Woodie C. Flowers, Ph.D.'73: One bridge collapsed instantly, designed without longitudinal stability; another resisted the heaviest load (46 lbs.) which could be measured by the scales available. A good lesson in engineering design, thinks Professor Flowers, and a good lesson, too, in what makes an engineering education at M.I.T.: "A sense of how to start with a blank piece of paper, and of how to think of yourself in society."

Professor Margaret L. A. MacVicar, '64, described the Undergraduate Research Opportunities Program (*U.R.O.P.—see February, 1973, pp. 78-83*): "Where in real life does someone find himself challenged by a series of questions to which the answers are known?" The idea of U.R.O.P., she said, is to let each student develop "his own special ways of solving problems"; too many students, she thinks, "accept the standard role, preparing them to be good but not great."

Deborah Hoover, '77, offered herself as an example: A year ago, as a freshman, she signed up for an Undergraduate Seminar in Ocean Engineering and found herself on a team of students designing an underwater robot-submarine for oceanographic exploration (*see June, 1974, p. 62*). "I couldn't believe I was in this project," she recalled for the teachers in the audience—she simply didn't feel she knew enough to do it. But she learned quickly, gained enthusiasm, and now wants to major in ocean engineering: "It's a field that just has to open up," she said—"our last frontier!"□

The Custodians and Cooks Take Their Case to the Sidewalks: A 26-Day Strike

For 26 days beginning September 12, M.I.T.'s maintenance and custodial employees (some 725 members of the Service Employees' International Union A.F.L.-C.I.O.) walked the Cambridge sidewalks in a picket line instead of in the Institute's corridors, classrooms, offices and greensward on their daily rounds. For most of that time they were joined by the 60 members at M.I.T. of the Cooks and Pastry Cooks Association A.F.L.-C.I.O., ordinarily employed in the dining halls and Faculty Club. Both groups were on strike after rejecting the terms of two-year contracts proposed by M.I.T. in negotiations which began before the previous contracts expired on July 1.

Though trash piled up, dining halls closed, mail service slowed, and some jobs were postponed, Institute business continued largely unaffected. That this was true can be credited largely to the way in which supervisors and volunteers manned critical jobs in the power plant and building maintenance—often at considerable personal inconvenience. Early in October *The Tech*'s headline was "Students O.K. Despite Strike," and Mitchell Trachtenberg '78, quoted one MacGregor House resident as saying, "We've had incredible success in keeping things clean."

Residents of the houses who count on dining halls for food were perhaps most inconvenienced; only Walker Memorial was open for meals, and only students with commons contracts were served there by Dining Service supervisory personnel, student staff members, and volunteer workers from Institute academic activities. Students from the West Campus with commons contracts found Walker a long walk before breakfast, and others who use Walker or the Student Center for occasional meals discovered that "it's damned expensive eating out all the time." Limited service was maintained at the Faculty Club under its contract with Stouffer Management Food Service.

There were few instances of friction between picketers and students, staff and faculty entering and leaving the Institute, and at the end of the four-week strike work resumed with no evidence of lingering animosity.

The Institute's offer to S.E.I.U. members was for 7½ per cent wage increases in each year of the 1974-76 contract, together with other improvements—changing from a contributory to noncontributory pension plan which would represent an additional three per cent increase for those who elected pension plan membership, increased vacations, increased medical coverages, decreases in the cost of contributory life insurance and a liberalized retirement plan. By the second year of the proposed contract, pay rates would be $4.21/hr. for custodians, $6.50/hr. for plumbers, $7/hr. for second class engineers, not including shift premiums or other differential pay.

The independent Research, Development, and Technical Employees' Union, representing some 850 laboratory workers throughout M.I.T. and Lincoln Laboratory, accepted a similar offer early in September. But the S.E.I.U. members did not—voting 222 to 202 for rejection when the offer was submitted to them without a favorable recommendation from their officers early in September.

Two weeks later, at a meeting on September 11 at 6 p.m. at the Institute—a time and place which might have discouraged many rank-and-file S.E.I.U. members from attending—came the strike vote, whose reported count was 165 to 140. A week later, the Cooks and Pastry Cooks joined the cause.

The break came on October 7, when the Federal Mediation and Conciliation Service brought M.I.T. and S.E.I.U. negotiators together. After 12 hours there emerged a proposal that S.E.I.U. members accepted on the following day, 343 to 195. The principal new provisions:

—Additional one per cent added to shift differentials, which had been four (3 to 11 p.m.) and six (11 p.m. to 7 a.m.) per cent.

—Several technical changes—increases of a few cents/hr.—in wages paid to certain tradesman classifications.

—A plan for M.I.T. to compensate retiring employees at their regular hourly rates for one-half their accrued sick leave if such leave exceeds 300 hrs.

—Modest increases in minimum pension payments, and a new plan for a committee of the Union to meet periodically with pension plan trustees.

—Revised and clarified funeral leave provisions.

—Full tuition benefits (instead of half tuition) to children of S.E.I.U. members who attend M.I.T. as undergraduates.

What will the new settlement cost M.I.T.? No certain answers, since the cost depends on how many union members choose to exercise some of its optional benefits. Another unanswerable question: Was the S.E.I.U. stronger for having led its members through the strikes? (Probably; but interviews with union members by *The Tech* and *Thursday* suggest that many are frustrated either by the fact of a strike or by its outcome.) One safe conclusion: Mid-October found M.I.T. returning to normal, neither union nor Institute apparently harboring reservoirs of ill will to temper future negotiations.□

Chancing the Wilderness In M.I.T.O.C.'s New Cabin

Imagine owning a beautiful cabin with most of the comforts of home on 20 acres near the White Mountain National Forest (New Hampshire). Utopia! Even more utopian if that land is rented for the sum of $1 a year!

That's what the M.I.T. Outing Club is camping out in these days—a far cry from the old, converted World War II building which is the Club's older cabin. In comparison to the "old cabin," with its stubborn stove and rudimentary sanitary facilities (an antiquated outhouse and the great outdoors), the "new cabin" is a joy to see and use. On land leased by North American Rockwell, the two-room cabin was built last summer by five outing club members who based their construction on a design by Peter M. Conant, M. Arch.'73, completed during his career as an architecture student.

Financing for the $13,000 cabin came from the Club's treasury and the Institute's grants and loans. A $3 membership fee, equipment and cabin rental, and the sale of M.I.T.O.C. books on rock climbing subsidize equipment replacement and repair, cabin maintenance, and an occasional newsletter; outing costs—mainly for gas and food—are shared by the participants.

Each weekend throughout the year, the Club sponsors several trips—ranging from easy day-hikes to extended winter camping treks—for those M.I.T.O.C. members and community afficianados interested in cross-country skiing, rock climbing, hiking, backpacking, ice skating, or canoeing. (Two years ago on an M.I.T.O.C.-affiliated snowshoeing jaunt, I first saw the land for the new cabin as I tentatively waddled upon crust-topped, two-foot-deep snow.)

Bruce MacKenzie, '74, an M.I.T.O.C. member, thinks the club gives the M.I.T. community a chance to escape the technological wilderness by getting out into the natural wilderness. This old M.I.T.O.C.er agrees—and so do lots of others.—*C.S.*□

Golden yellow in the sunshine, M.I.T.O.C.'s new cabin sits in the midst of a $1-a-year utopia. Shown here are the cabin—during the building stage and as the finished product—and two of the student workers who helped construct it. (Photos: Mike Shakespear, '73.)

Approaching the grandstand and the finish line at the World Rowing Championships in Lucerne in August, 1974, the U.S. Heavyweight Eight had just passed the U.S.S.R. boat when this photo was taken. The results: a gold medal for the United States, and a fifth-place showing for the Russians. John Everett '76, is in the three-seat of the far boat. (Photo: R.E. Hopfner copyright)

M.I.T. Crew: Bringing the Gold Home

Being a coxswain has its advantages and disadvantages. One disadvantage is that you have to exercise on your own time in order to remove the fat accumulated on your body from sitting through the whole season in the stern of a boat. But one advantage is that you can cox during practice for any team you want—heavyweight, lightweight, men, women.

During the past year when I was Women's Varsity Coxswain for M.I.T., I assisted on both the men's heavyweight and lightweight teams. While I coxed for them, I got to know many of the team members, among them Gary Piantedosi, '76, and John Everett, '76, of the heavyweight squad, and Peter Billings, '73, and Ralph Nauman, '74, formerly of the lightweight team. What do these four guys have in common?

First, they were all members of the United States Rowing Team (John and Ralph in the two eight-oared shells; Gary and Pete as spares, or alternates) that competed in the World Rowing Championships in August in Lucerne, Switzerland.

That's no small honor in itself. The U.S. Rowing Team is the equivalent of the "All-American" teams in most other college sports—the best athletes in the nation. The "team concept" is new to crew—three years ago, thanks in part to the efforts of Jack H. Frailey, '44, was the first heavyweight team, and this year's was the first lightweight team ever designated.

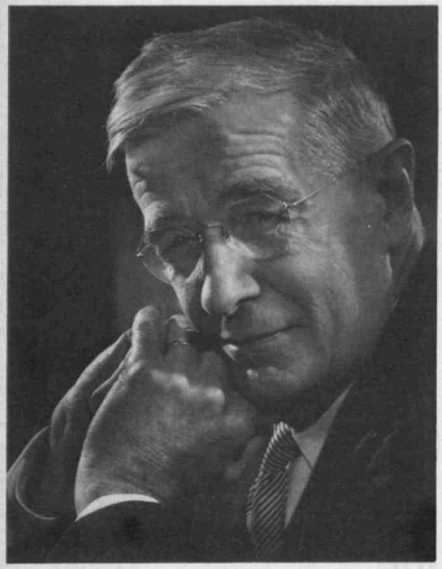
Secondly, both lightweight and heavyweight boats just happened to win their respective events, bringing home gold medals in international competition. Bill Miller, M.I.T. Varsity Lightweight Coach, went to Lucerne after taking the U.S. title in coxed pairs and his boat placed ninth in the coxed pairs event (two oarsmen with coxswain) in Switzerland. In 1969, Miller was seventh in the World Championships, but the competition has improved since then and he feels that ninth was "respectable" this year.

Jack H. Frailey, '44, former M.I.T. crew coach who is Director of Student Financial Aid, was also on hand at Lucerne as U.S. chief delegate to the International Rowing Congress. As reported by Glenn Brownstein, '77, in *The Tech*, "Coach" Frailey attributed the U.S. victories to "the control and calm exhibited . . . in their gold-medal efforts."

John and Gary are the two most effective oarsmen on the heavyweight squad. Pete is this year's Freshman Lightweight Coach and a former member of the U.S. team; Ralph was last year's Lightweight Captain and voted Most Inspirational Oarsman by the squad.

None of these oarsmen typifies the stereotyped world champion athlete; each is a serious student, and each looks forward to the 1976 Olympics and the tough training schedule that will precede them. Indeed, this championship attitude is typical of every member of the M.I.T. crew teams; no wonder I'm proud of them!—*C.S.*□

People



Vannevar Bush (Photo by Karsh)

Vannevar Bush: Paradigm of Engineer—But What of the Joy of Singing?

How to characterize Vannevar Bush, '16—scientist, engineer, teacher, administrator, philosopher, naturalist?

All those, and more. Hence the extraordinary diversity, warmth, and interest of the tributes paid to him by four friends and colleagues at a memorial service in Kresge Auditorium on October 4. The four: James R. Killian, Jr., '26, Honorary Chairman of the Corporation, who knew Dr. Bush at M.I.T. as teacher and administrator; James B. Conant, President Emeritus of Harvard University, who was Dr. Bush's World War II colleague and confidante in Washington; Caryl P. Haskins, Dr. Bush's successor as President of the Carnegie Institution of Washington; and the Reverend Daniel Novotny, Pastor of the Plymouth Congregational Church in Belmont, Mass.

Dr. Bush was first an engineer—"a seminal figure in the ongoing development of computers of all kinds," said Dr. Killian; and he quoted the *New York Times* obituary in which Robert Reinhold called Dr. Bush "the paradigm of the engineer—a man who gets things done."

Dr. Conant recalled a message from Dr. Bush, then a member of the National Advisory Committee for Aeronautics in which Dr. Bush expressed concern at the relative slowness of the American as compared with the German airplane program. "I knew nothing about airplanes," said Dr. Conant, "but if Van was worried, we all ought to be worried, too."

But for an engineer he shared—and remarkably understood—much of the spirit of science. Dr. Bush was "the primary link between science and technology" during development and building of the atomic bomb, said Dr. Conant; and after World War II the report he persuaded Franklin D. Roosevelt to ask him to write (Dr. Killian's phrase) provided the model for the organization of the National Science Foundation and continues "to color much of our science today," said Dr. Haskins.

"An Event of Historic Significance"

Dr. Bush's arrival in the M.I.T. Department of Electrical Engineering as a member of the faculty in 1919 began what Dr. Killian described as a "dazzling period," and he quoted Harold L. Hazen's ('25) recollection of Vannevar Bush as teacher: ". . . by the time that hour was over, each of us had been so intensively infused with a whole raft of new and stimulating ideas that the subsequent subconscious as well as conscious learning processes, I am sure, led us eventually to a profound command of the idea. . . ."

President Karl T. Compton asked Dr. Bush to become Dean of Engineering and Vice President of the Institute in 1932, and so began, said Dr. Killian, "a powerful administrative team which gave to M.I.T. one of its great periods"; Dr. Bush was "a superlatively effective administrator." Dr. Conant cited the same talents in paying tribute to Dr. Bush's World War II work plan for mobilizing science: "It was a collection of innovations, made possible by the human and practical understanding, the imagination, integrity, and humor of this remarkable man."

In role if not in title, Dr. Bush was the first Presidential science adviser in the U.S., thinks Dr. Conant, probably the single one of all who have followed with the best rapport with his President. The fact is that Dr. Bush and President Roosevelt "hit it off at once. . . . I think it is not too much to say that Dr. Bush's first conference with the President was an event of historic significance," Dr. Conant said.

"I Have Become Acquainted with a Catbird . . ."

Beyond all this, Dr. Bush was a remarkable human philosopher. The contrast of determinism and free will—two aspects of man's being—is a persistent theme in his writing, Mr. Novtny noted: "The process of evolution could not account for our rejoicing in beauty and love," thought Dr. Bush. And rejoice he did—a persistent and undispairing rooter for the Red Sox, an avid trout fisherman, sailor.

"Do birds sing for the joy of singing?" asked Dr. Bush in the foreword to *Pieces of the Action,* and he proceeded to speculate that they surely did, that no other judgment could account for the complexity and beauty of their song. "I have become acquainted with a catbird," he wrote (as Dr. Killian recalled), "who obviously derives pleasure as he tries out little phrases on his own."

When it came time to designate beneficiaries for the royalties of *Modern Arms and Free Men,* Dr. Bush determined to give half to the Carnegie Institution (the other half came to M.I.T.) with the stipulation that the funds be used by the Institution's staff for something that, in their view, would most contribute to their renewal, requiring only that it have no direct relation to their work. The result was two Vannevar Bush retreats—simple resorts for the use of Carnegie Institution staff and families.

When he learned of the decision, said

Dr. Haskins, Dr. Bush was pleased: "Scientists need recreation," Dr. Bush said. "So does everyone else, for that matter. But the need of scientists has certain special characteristics because of the nature of their work . . . a pause that renders the work that follows more pleasant and more fruitful."□

M.I.T. Appointments: Shifting and Changing

Twelve new appointments affecting M.I.T.'s academic and administrative staffs announced during the fall:

—**Walter A. Alessi**, former all-American lacrosse star from the University of Massachusetts, has been named varsity lacrosse coach; he succeeds Benjamin R. Martin, Jr., who retired this summer after coaching lacrosse and hockey at M.I.T. for almost 30 years. Mr. Alessi will continue his full-time duties as teacher and assistant football and basketball coach at Westwood High School.

—**Allan S. Bufferd**, '59, formerly Associate Director of the Alumni Fund, has been named Institute Secretary in the field of trusts and bequests, a member of the staff of James B. Lampert, Vice President for Resource Development; he will be associated with D. Hugh Darden. Dr. Bufferd joined the Alumni Fund staff in 1972 after a successful career in the field of metallurgy, in which he holds bachelor's and advanced (S.M. 1961, Sc.D. 1965) degrees from M.I.T.

Project MAC, the Institute's laboratory for advanced research in computer science and engineering, has new leadership: Professor Joel Moses, Ph.D.'67, Associate Director (left), is an authority in the use of computers for complex mathematics; and Professor Michael L. Dertouzos, Ph.D.'64, Director, is a specialist in control robotics—the use of computers for controlling physical processes—and in programming languages.

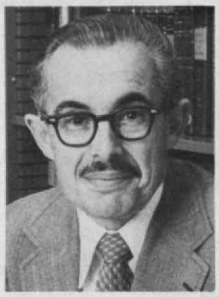
—**Michael L. Dertouzos**, Ph.D.'64, Professor of Computer Science and Electrical Engineering, has been named Director of Project MAC, the Institute's laboratory for advanced research in computation. Professor Dertouzos' connections with Project MAC began with the laboratory's founding, and he has studied and taught in the field of digital systems and logic since then. The laboratory's present research includes programming, languages for man-computer communications, privacy systems, computer structures and limitations, and computer applications. Professor Dertouzos succeeds Professor Edward Fredkin, who will return to full-time teaching and research.

—**Samuel A. Goldblith**, '40, Underwood-Prescott Professor of Food Science, is now Director of the M.I.T. Industrial Liaison Office, supervising its arrangements for formal liaison between the Institute and a group of participating industries. Professor Goldblith says his goals will be to improve the quality of services to present members and to encourage additional industries to join. Dr. Goldblith has been a member of the faculty in the field of food technology since returning from World War II service, during which he spent 42 months as a Japanese prisoner-of-war. He will continue teaching but will give up his administrative duties as Associate Head of the Department of Nutrition and Food Science.

—**Marcus Karel**, Ph.D.'60, Professor of Food Engineering whose teaching and research are in food processing and chemistry, is Deputy Head of the Department of Nutrition and Food Science; he succeeds Professor Samuel A. Goldblith (*see above*). Dr. Karel first came to M.I.T. as a technical assistant to Professor Goldblith in studies of the preservation of foods by radiation. He was born in Poland, studied agriculture at the Technische Hochschule in Munich, and holds degrees from Boston University (A.B. 1955) and M.I.T., where he joined the faculty a year after completing his Ph.D.

—**Vera Kistiakowski**, Professor of Physics, now holds the Gilman Fellowship, which puts her in charge of activities under a Carnegie Corp. project to help women at M.I.T. develop and realize professional career plans. She plans a "road show" of students, alumnae, and other professional women prepared to visit M.I.T. departmental and living groups, and internships will be open to undergraduate women who want to explore fields in which they're interested.

S. A. Goldblith



M. Karel

L. Menand

J. B. Turner

—**John L. Mack**, '73, has been appointed Staff Recruiter in the Personnel Office; his job will be to help Institute departments and offices find qualified applicants for openings, with special emphasis on members of minority groups and women. Mr. Mack's M.I.T. degree was in urban studies and planning.

—**Louis Menand, III**, who has been Assistant to the Provost, has been promoted to Senior Lecturer in the Department of Political Science, where he will teach American politics and constitutional law. He will also continue a part-time affiliation with the Office of the Provost as Special Assistant for field work programs and environmental education. Dr. Menand holds degrees from Middlebury and the Maxwell School of Public Administration at Syracuse University, and he came to the Institute in 1968 from a position with Educational Associates, Inc., consultants in Washington, D.C.

—**Joel Moses**, Ph.D.'67, Associate Professor of Computer Science and Engineering, is Associate Director of Project MAC, where he will be associated with Professor Michael L. Dertouzos (*see above*) in the direction of programs in computer development and applications. Professor Moses' academic work is in mathematics; he came to the U.S. from Israel in 1954, studied at Columbia (A.B. 1962, A.M. 1963) before entering M.I.T., and joined the M.I.T. faculty in 1967. He is the author of MACSYMA, a large symbolic manipulation system.

—**Clevonne W. Turner**, who specializes in academic and personal counseling for minority students, is Acting Assistant Dean for Student Affairs, substituting in the Dean's Office for Mary O. Hope, who is on leave of absence through February 1, 1975. Mrs. Turner, whose husband has joined the Graduate School staff (*see below*), is the co-designer of an orientation course for minority students at Indiana University entitled "Now That I'm Here, How Will I Survive?"

—**John B. Turner**, a specialist in student personnel administration, is Assistant Dean for Minority Graduate Students; he succeeds Clarence G. Williams, who is now Special Assistant to the President and Chancellor for Minority Affairs. As Dean, Dr. Turner will be responsible for minority students in the Graduate School and for programs to encourage additional minority students to come in the future. A graduate of Fisk University (B.A. 1965) and Indiana University (M.S. 1968, Ed.D. 1972), Dr. Turner has been Assistant Dean of the Freshman Division at I.U. since 1968.

—**Clay T. Whitehead**, '60, former Director of the U.S. Office of Telecommunications Policy, has two jobs in Cambridge this year: He is Research Associate in the Center for International Studies at M.I.T. and a Fellow at the Institute of Politics in the Kennedy School of Government, Harvard. Mr. Whitehead will work on a study of U.S. communications policy; his M.I.T. appointment is funded by a Markle Foundation grant.□

A Prize for Food in Space . . . and on Earth

The food developed for American astronauts on the Apollo and Skylab missions by the three men on the left will not end up in American supermarkets. But their work moved nutrition a few steps along the road to an exact science and brought them M.I.T.'s Underwood Prescott Memorial Award for 1974. President Jerome B. Wiesner is shown presenting citations to (left to right) Dr. Paul C. Rambaut, Sc.D.'66, Chief of Nutrition; Dr. Malcolm C. Smith, Jr., Chief of the Food and Nutrition Branch; and Dr. Norman D. Heidelbaugh, Ph.D.'70, Chief of Food Science—all at N.A.S.A.'s Johnson Space Center.

What do you feed a spider in space?

When it spotted the word "feed," the computer sent the question to Malcolm C. Smith, Jr., at the Lyndon B. Johnson Space Center, Houston. A tribute to the computer, yes—but also, thought the committee selecting the winner of M.I.T.'s 1974 Underwood-Prescott Memorial Award, a tribute to the Food and Nutrition Branch, of which Dr. Smith is head.

Three scientists—"without the teamwork and leadership of these three men, the Skylab mission would have been impossible," President Jerome B. Wiesner said in presenting the Awards—were finally chosen: Dr. Smith, Norman D. Heidelbaugh, Ph.D.'70, Chief of Food Science at the Johnson Space Center, and Paul C. Rambaut, Sc.D.'66, the Center's Chief of Nutrition. There was $1,000 for each of them, provided by the William Underwood Co., and at the ceremony it was announced that each would give his prize money to philanthropy, two of them to M.I.T.

Just as there is on the ground, there's more than simply science to food in space. Why does the Underwood Co. wrap its cans of deviled ham in paper wrappers? Dr. Heidelbaugh knows: Because "foods are an emotional subject . . . as emotionally involved with man as sex and motherhood," he said in a paper on space food technology following the award ceremony. And food for space (though solidly based in science and involving a new kind of engineering) has to reckon with the emotional as well as the nutritional needs of the astronauts.

Another dimension of the award was noted by President Wiesner as he recalled President John F. Kennedy's concern for using space to benefit mankind on earth: "He would have taken pride in Skylab," President Wiesner said, and in the work of the three awardees, since Skylab food developments will have "important implications for food supplies on earth."□

Three Professorships in the Sloan School

Three members of the Sloan School of Management faculty have been honored by appointment to distinguished professorships:

—**Paul W. MacAvoy**, Professor of Management, is now Henry R. Luce Professor of Environment and Public Policy.

—**Edward B. Roberts**, '57, Professor of Management, has been named David Sarnoff Professor for a three-year term beginning in July, 1974.

—**Carroll L. Wilson**, '32, Professor of Management, is the first Mitsui Professor in Problems of Contemporary Technology.

The Luce Professorship, first held last year by the distinguished French scientist Pierre R. Aigrain, was established by the Henry Luce Foundation, Inc., to support work on public policy implications of the impact of technological advances on natural systems. It is a logical appointment for Professor MacAvoy, whose work encompasses some of the major government-industry policy issues of the day: energy and environmental policies and government regulation of energy, transportation, and communications industries.

At M.I.T. since 1963, Professor MacAvoy has been a Senior Fellow at the

P. W. MacAvoy

E. B. Roberts

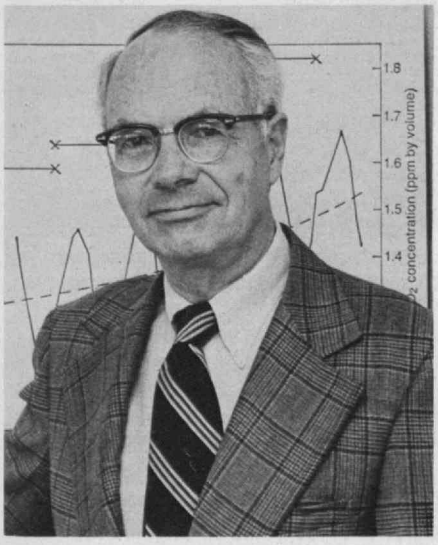
Brookings Institution, a staff member of the Ford Foundation, a member of the senior staff of the President's Council of Economic Advisers, and consultant on international development and anti-trust. His degrees are from Bates College (A.B. 1955) and Yale (M.A. 1956, Ph.D. 1960).

Professor Roberts succeeds the late Donald G. Marquis as Sarnoff Professor; both were authorities in the management of research, development, and technology-based innovation, which is the field of the Sarnoff Professorship. It was endowed at M.I.T. in 1972 by the RCA Corp. as a tribute to its long-time Chairman.

Professor Roberts is now chairman of the Sloan School's group studying the management of technology and health-care delivery; he has written extensively on technical entrepreneurship and research and development management. His academic work was at M.I.T., where he has earned four degrees: S.B. and S.M. (1958) in electrical engineering, S.M. (1960) in management, and Ph.D. (1962) in economics.

The Mitsui Professorship, whose first incumbent is Professor Wilson, results from a $1 million gift, announced early this year, from the 30 companies of the Mitsui Group in Japan. Professor Wilson's qualifications for it are clear: He has been instigator and director of a number of activities on problems accompanying scientific and technological change and other world-wide implications of industrial development, and he is now directing a study of energy options for the developed nations.

Professor Wilson was the first General Manager of the U.S. Atomic Energy Commission from 1947 to 1950. Between then and 1959, when he joined the teaching staff at M.I.T., he held a number of important industrial posts, and he now has a wide range of consulting and advisory assignments relating to international development and scientific problems.□



C. L. Wilson

On Being a Faculty Resident: "An Extension of the Faculty" and "It's Nice to Walk to Work"

Being a faculty resident in a large dormitory such as MacGregor House could be a difficult job, but to Professor William G. Thilly, '67, and his wife, Diane, "It's nice to have lots of people around." For Professor Thilly that's not much of a change, since he's usually surrounded by half a dozen students in his toxicology (nutrition) laboratory; but Mrs. Thilly likes the company. And as for his ten-month-old son, William F., "he just smiles at everybody."

After leasing their home in Somerville, the Thillys moved into the top floor of MacGregor, succeeding Professor Ernest G. Cravalho, (Department of Mechanical Engineering) and his family. By mid-October they had met roughly 200 of MacGregor's 326 residents, most of them through the weekly study breaks at which the Thillys offer food, drink, and a willing ear. As Professor Thilly envisions his position, "We're here as an extension of the faculty—a role many more would enjoy but for other commitments."

How did they find the opening? Simple. Someone nominated them, and they accepted when asked if they would like to be junior faculty residents. Professor Thilly admits that the job isn't—so far—as hard as he had expected. "The students are certainly mature enough to handle their own problems. What duties there are, are enjoyable, and it's nice to be able to walk to work."

Although there may not be any major problems facing the Thillys at present, they are well-equipped to handle a variety of upsets. Diane Thilly, an alumna of B.U. and Northeastern University, is a lawyer who maintains a private practice in criminal, real estate, and family law; she is also an associate of the firm of Barbara Hayes Buell in Somerville. A Lilly Teaching Fellow, Professor Thilly took both his Bachelor's and Doctoral (1971) degrees from M.I.T. and was recently awarded the Everett Moore Baker Award for outstanding undergraduate teaching.

The Thillys are among three faculty couples who began duties as residents this fall: Professor Robert I. Hulsizer Jr., Ph.D.'48, of the Department of Physics, and Carol Hulsizer, free-lance editor, are now faculty residents in Ashdown House; and Assistant Professor Ronald G. Prinn, Sc.D.'71, of the Meteorology Department, and Jane Prinn, a secondary school Spanish teacher, have moved from Winchester into Baker House as the junior faculty residents.□

Nutrition, law, physics, Spanish, meteorology, and literature have come to M.I.T. houses this fall with three new faculty resident couples. Professor and Mrs. Robert I. Hulsizer (top) are in Ashdown House; he teaches physics and she does free-lance editorial work. MacGregor's junior faculty residents are Professor and Mrs. William G. Thilly (center, with 10-month-old William F.); he teaches toxicology in the Department of Nutrition and Food Science, and Mrs. Thilly maintains a private practice in criminal, real estate, and family law. Jane Prinn teaches junior high school Spanish in Winchester, Mass.; her husband is Ronald G. Prinn, Assistant Professor of Meteorology, and they (below) are junior faculty residents in Baker House.

An Innovator Coming to Head Advanced Study

M. Tribus

Myron Tribus, a distinguished engineer who has been a champion of technological innovation in government and industrial assignments, will come to M.I.T. on January 1 to be Director of the Center for Advanced Engineering Study.

Dr. Tribus is now Corporate Vice President—Research at Xerox Corp.; he will succeed Wilbur B. Davenport, Jr., Sc.D.'50, former C.A.E.S. Director who has continued on an acting basis since becoming Head of the Department of Electrical Engineering early this year.

At Xerox since 1970, Dr. Tribus has been in charge of research and development for the copier/duplicator portion of the product line and earlier was associated as Vice President with the Xerox Information Technology Group; in these assignments, especially, he has concentrated on stimulating innovation and turning inventions into profitable industrial investments.

Earlier, his interests in technology and innovation led to his appointment in 1969 as Assistant Secretary of Commerce for Science and Technology, where he was in charge of the wide-ranging technical activities which are centered in the Department of Commerce.

Dr. Tribus, who will also be a member of the faculty as Professor of Engineering, studied at the University of California in Berkeley (B.Sc. in chemistry, 1942) and in Los Angeles (Ph.D. in engineering, 1949). For eight years beginning in 1953 he was Associate Professor of Engineering at U.C.L.A., specializing in heat transfer and thermodynamics, and in 1961 he became Dean of Engineering at Dartmouth College (Thayer School of Engineering); here he developed programs in engineering design and first became involved in water resources, the process of innovation, and decision theory.

Dr. Tribus has been widely honored with awards and honorary degrees, and he is a member of the National Academy of Engineering, Phi Beta Kappa, and Sigma Xi. He serves on the Board of Directors of SCORE (Student Competitions on Relevant Engineering) and the Board of Governors of Technion, Haifa, Israel.□

Individuals Noteworthy

Kudos: Honors, Awards, and Citations

Six M.I.T. alumni were honored by the American Institute of Architects: **Ralph Knowles,** M.Arch. '59, received the 1974 Medal for Research . . . **Kevin Lynch,** '47, received the 1974 Allied Professions Medal for his work in urban design and environmental planning . . . **Armand Bartos,** M. Arch. '35; **Harry A. Golemon,** M. Arch. '52; **David M. Scott,** '55; and **Rolland D. Thompson,** S.M. '49, advanced to the position of Fellow by the A.I.A.

To **James B. Fisk,** '31, the Advancement of Research Medal of the American Society for Metals . . . to **Norbert L. Kusters,** S.M. '39, the Morris E. Leeds Award of the Institute of Electrical and Electronics Engineers, "for inspiring leadership in the field of electrical measurements, in particular for the development of the current comparator and its associated applications" . . . to **George M. Whitesides,** Professor of Chemistry at M.I.T., the $2000 Award in Pure Chemistry of the American Chemical Society for 1975 . . . to **Henry Melson Stommel,** Research Associate with the Woods Hole Oceanographic Institution and Professor of Oceanography at M.I.T., the Henry Bryant Bigelow Medal from the Woods Hole Oceanographic Institution for his "contributions to our understanding of ocean circulation and dynamics, for his leadership in theoretical and experimental marine science, and for his profound influence on the advance of oceanography throughout the world."

To **David Baltimore,** American Cancer Society Professor of Microbiology at M.I.T., the $5000 Gairdner Foundation International Award for "innovative and significant research on the mechanism of action of viruses in relation to tumor production" . . . to **Bruno B. Rossi,** Institute Professor, Emeritus, the Elliot Cresson Medal of the Franklin Institute of Philadelphia "for his many important contributions to our understanding of cosmic rays, and for his pioneering work in space physics, and gamma-ray and X-ray astronomy" . . . to **Lawrence E. McCray,** Ph.D.'74, Research Associate in the M.I.T. Center for International Studies, the E. E. Schattschneider Award of the American Political Science Association for his dissertation "The Politics of Regulation: Multifirm Trade Associations in Telecommunications Policy Making" . . . to **Fred Kochendorfer,** S.M.'49, the Medal for Exceptional Scientific Achievement from the National Aeronautics and Space Administration for his leadership in the administrative and financial management of the Pioneer Program.

G. M. Whitesides

R. J. Musser

Clay T. Whitehead, '60, Research Associate at the M.I.T. Center for International Studies, was named a Fellow of the Institute of Politics at Harvard's John F. Kennedy School of Government . . . **Ferdi B. Stern,** Jr., S.M. '40, was awarded the position of Fellow of the American Society for Nondestructive Testing . . . **Thomas Dudley Cabot,** life member of the M.I.T. Corporation, received the annual Conservation Award of the Trustees of Reservations.

Norman W. Stoldt, S.M.'71, was decorated with the U.S. Air Force Commendation Medal for meritorious service as the U.S.A.F. Environmental Technical Applications Centers' liaison with the National Space Science Data Center, N.A.S.A. . . . **Max K. Kennedy,** S.M. '62, received the Air Force Civilian of the Year Award of the Air Force Association . . . to **Karl R. Merrill,** S.M. '66, the Meritorious Civilian Service Award . . . and to **Jack C. Greene,** '47, former Deputy Assistant Director for Research in the Defense Department's Defense Civil Preparedness Agency, the D.C.P.A. Distinguished Civilian Service Award.

Jack C. Greene '47, left, receives the Distinguished Civilian Service Award.

Appointments: Rising in the World of Business

Arthur A. Smith, '31, Executive Vice President of Stone and Webster Engineering Corp. after 30 years in engineering management with the company . . . **Paul Wing, Jr.,** '34, Vice President—Engineer-

ing of Masoneilan International, Inc., in charge of worldwide research and development activities . . . **Walther H. Mathesius**, '36, Manager of Engineering for U.S. Refractories Division, General Refractories Co., Pittsburgh . . . **Donald F. Holloway**, '38, formerly Manager of Research and Development at Wisconsin Leather Co., Technical Director of General Split Corp., responsible for technical work in tanning, finishing, and new product development . . . **Frank B. Kemp**, '38, after 15 years with Compton Advertising, Inc., Executive Vice President of Walpert Co., Inc., advertising, marketing, and public relations firm in Cherry Hill, N.J.

C. William Ritterhoff, '47, Executive Vice President and Director of Bethlehem Steel Corp. after 25 years in engineer and operations for the company . . . **Stanley I. Landgraf**, '47, President and Chief Operating Officer of Mohasco Corp., carpets and interior furnishings . . . **Joseph L. Boscov,** S.M.'47, incorporating H B Engineering Corp. into Berk-Tek, Inc., manufacturer of electronic wire and cable, of which he continues as President.

Frank A. Jones, Jr., '48, President of Cook Industries, Inc., Memphis (agri-business: building products, pest control, and insurance) . . . **Ross O. Watson**, '49, Assistant General Manager of the Organics Department, Hercules, Inc. . . . **Edward Dinowitz**, '49, Manager of Engineering at Instron Corp. . . . **Charles H. Fargo**, '51, President of C. H. Fargo and Co., a new real estate firm in industrial, commercial, and investment properties; **Francis C. Rogerson, Jr.**, '55, is one of four other partners.

William L. Demiene, M.Arch.'57, Senior Architectural Designer at Albert Kahn Associates, Inc., architects and engineers, Detroit . . . **Christopher J. Ward**, '60, Assistant Treasurer of Kaiser Steel Corp. . . . **Craig S. Tedmon. Jr.**, '61, Manager of the Power Systems Laboratory, General Electric Research and Development Center, Schenectady . . . **Charles J. Touhill, Jr.**, S.M.'61, Chairman and Chief Executive Officer of Morris Knowles, Inc., engineering and consulting firm, Pittsburgh; Dr. Touhill is a specialist in waste water treatment and resources management . . . **Peter Brown**, '62, Executive Vice President of Audubon Properties, Inc. (community development), Hollywood, Fla. . . . **Chong-Jin Lee**, Sc.D.'65, Director of Planning Analysis for AMF, Inc., responsible for analyzing company plans and developing worldwide planning systems . . . **Robert Moser**, S.M.'74, Assistant to the Vice President—Personnel, Baxter Laboratories, Inc.

Three appointments at Analog Devices, Norwood, Mass.: **Benjamin Z. Ranan**, '47, Director of Manufacturing, Modular Instrumentation Division . . . **A. Graham Sterling**, '48, Director of Planning and Control . . . **Modesto A. Maidique**, '62, Vice President and General Manager, Semiconductor Division.

New assignments for former Sloan Fellows: **Paul A. Heinen**, S.M.'63, Vice President, Associate General Counsel, and Secretary of Chrysler Corp. . . . **Robert F. Calman**, S.M.'67, Executive Vice President of IU International Corp. in charge of electric and gas, water and waste management, natural resources, communications, dental distribution, and laboratory operations . . . **Peter S. Hepp**, S.M.'68, Vice President and Director of Sun Oil Co. of Pennsylvania (Products Group), the domestic marketing, manufacturing, and transportation subsidiary of Sun Oil Co. . . . **R. Anderson Pew**, S.M.'70, Corporate Secretary of Sun Oil Co. . . . **Wendell W. Larsen**, S.M.'68, Vice President—Public Relations at Chrysler Corp.

George W. McKinney III, '65, Assistant Treasurer of Corning International Corp. . . . **Williard B. Ferguson**, '51, Manager of Customer and Marketing Services for U.S. Sales, Perkins-Elmer Corp. . . . **F. Cort Turner,** '49, Vice-President Arthur D. Little, Inc. . . . **Robert J. Musser**, S.M.'47, Director of Planning, Union Carbide Europe, Inc. . . . **John W. Bremer,** '54, Director of Advanced Technology Programs for Honeywell Information Systems . . . **John M. Roblin,** S.M.'55, Manager of Process Materials Planning, Republic Steel Corp. . . . **Robert L. McCormack**, '33, Vice President of Manufacturing, Raytheon Co. . . . **Martin Weinstein**, Sc.D.'61, Executive Vice President and General Manager of Turbine Support Division, Chromalloy American Corp.

Contributing New Ideas

Nevin S. Scrimshaw, Chairman of the Department of Nutrition at M.I.T., will be a contributor to the publication of the PAG Compendium, a study of the World Food situation, issued by the Protein-Calorie Advisory Group of the United Nations Systems. . . . "Night Voices," a new work for young people commissioned from M.I.T. Conductor-Composer **David Epstein** and his wife, **Anne Epstein,** was performed this fall as part of the Youth Concerts at Symphony Hall by the Boston Symphony Orchestra. . . . **Gyorgy Kepes**, Institute Professor, Emeritus, in the M.I.T. Department of Architecture (he was founder and first Director of the Center for Advanced Visual Studies) is spending the current academic year at the American Academy in Rome; he will continue painting, will work on two writing projects, and will return to his native Hungary for an exhibition of his works in Budapest. The writing projects are on light as a creative architectural medium and on public art.

Deceased

Alvan L. Davis, '98; February 4, 1974
Walter L. Rapp, '00; March 4, 1974
Oliver M. Wiard, '04; July 31, 1974
Arthur T. Balkam, '05; July 15, 1974
Frederick P. Poole, '05; September 4, 1974
A. Warren Wells, '05; September 21, 1974
George A. Griffin, '07; August 3, 1974*
Austin B. Henderson, '09; March 25, 1974
Arthur R. Knipp, '09; August 27, 1974
Robert C. Latimer, '09; June 6, 1974
Archie McEachern, '09; June 17, 1971
George E. Goodspeed, '10; August 15, 1974
Oscar J. Gilcreest, '11; November 11, 1973
Ruth D. Tolman, '11; September 4, 1974*
Dolphe Martin, '12; October 4, 1974
Philip V. Burt, '13, July 30, 1974*
Lawrence H. Bailey, '15; October 1, 1974*
George A. Spooner, '16; June 6, 1974
Charles E. Atkinson, '17; May 20, 1974
Max J. Mackler, '17; September 12, 1974*
Arthur H. Paul, Jr., '17; March 16, 1974*
John A. Steere, '18; July 24, 1974*
Philip L. Rhodes, '19; August 30, 1974*
Ralston B. Smyth, '19; January 12, 1974*
Andrew T. Johnson, '20; August 5, 1974
Abraham M. Aronson, '21; June 5, 1974
James F. Curtin, '21; August 30, 1974
Henry N. Hallett, '21; October 2, 1974
H. Clifford Gayley, '22; October 19, 1974*
Adrian J. Gilardi, '22; January, 1974
Bennett H. Levenson, '22; July 13, 1974
Raymond T. Willis, '23; April 18, 1974
Samuel J. Kogan, '24; August 28, 1974*
E. H. Mitcham, '25; December 28, 1973
Gilbert H. Sechrist, '25; September 14, 1974
Charles M. Smith, '25; August 4, 1974*
Barnett S. Gruzen, '26; September 27, 1974*
Willard Dodge, '29; June 30, 1974*
Wendell E. Kraft, '29; July 15, 1974*
George H. Schumacher, '29; June 27, 1974
V. Edwin Ware, Jr., '29; December 31, 1973*
Norman M. Yeretsky, '30; September 25, 1974
Charles B. Bradley, '32; August 9, 1974
Bernard F. Doucette, '33; April 16, 1974
Thomas M. Hayden, '33; June 26, 1974*
Robert E. Mann, '34; June 9, 1974
Merton S. Neill, '34; August 21, 1974
Charles S. Taylor, 2d, '35; October 8, 1974*
Almon W. Manlove, '40; June 13, 1974
Eduardo G. Dibos-Chappuis, '47; October 15, 1973
Richard L. Hoff, '47; March 8, 1973
Douglas Jones, '51; August 19, 1974*
Bernard D. Ross, '52; July 28, 1974
Neil R. MacFarlane, '58; September 8, 1974
Burton W. Whiteley, '59; November 7, 1973
David L. Markusen, '71; August, 1974
Richard A. Ziebelman, '71; July 8, 1974
*Further information in *Class Review*

Class Review

94

The oldest M.I.T. alumni, **Caroline Whitney Barrett** of Ipswich, died on July 19 at the age of 104. Mrs. Barrett was born in 1870—a year after President Ulysses S. Grant assumed office. It was her brother, Dr. Willis R. Whitney, an M.I.T. professor, who interceded in her behalf when she sought a college education, then a privilege seldom granted to a young woman. After the Chelsea fire of April 12, 1908, Mrs. Barrett asked the city of Boston to lease her 10 sewing machines, which she and her Brookline neighbors used to make clothes for the homeless Chelsea victims. She is survived by two daughters, Mrs. Agnes Wendel and Jean Barrett, both of Ipswich; two grandchildren and five great grandchildren.—M.L.

96

It is a beautiful warm Indian Summer day on the Massachusetts shore, but it is time to extend holiday greetings to all. May both our centenarians enjoy the Christmas gatherings with their families.

On October 23 Will Coolidge celebrated the first birthday of his second century. Your Secretary phoned to extend greetings from the Class and learned that all is well at the '96 outpost in Schenectady.—**Clare Driscoll**, Acting Secretary, Cliff St., Plymouth, Mass. 02360

03

What a thrill for our entire Alumni M.I.T. ensemble, especially our remaining Class of 1903, to read the astonishing news of Purdue University, $6.1 million gift, a Research Engineering Centre, to our Emeritus Professor, **Audrey A. Potter**, M.I.T. 1903.

Yes Audrey, this is most unusual news to any university alumnus, to have a laboratory named for one of their graduates, in place of an outside benefactor. Your long and faithful teaching at Purdue University was as head of the Engineering Department, acquiring many honorary degrees since 1920. The honor was bestowed at a public luncheon in May. The Audrey A. Potter Building will house classrooms and laboratories for electrical engineering and electrical technology.

Our Class was well represented last June on Alumni Day, with our neighbor Class Secretaries, also devoid of our mature

A drawing of the Audrey A. Potter Research Engineering Center is held up for Mr. Potter, '03, at a luncheon in May when he was honored at Purdue University.

Classmates. We were gratefully honored by the M.I.T. photographer for our group picture and publication by Mr. Mattill in the July/August *Review* as a memory. . . . Another welcome letter of interest for our alert remaining classmates of '03 comes from **Charles B. Cox I**, 503 Orondo Ave. Wenatchee, Wash. Barry is extremely loyal, though recently entering his 90th year corral, after a long period of active successful life. His birthday and 60th wedding anniversary was well enjoyed by his many friends and neighbors. He is unusually interested in our present Classmates association. He desires their name and address from the Alumni Office and will gladly secure them. He is aware of our Classmates lethargy, so sends a set of questions to facilitate a response. Question (1) name, (2) present age, (3) course at M.I.T., (4) marital status, (5) present health, (6) a daily schedule and (7) a noteworthy event during their busy career. So, Classmates, we await your sincere response.

Mr. **Phillip Bernard Rice**, aged 93, died on Friday, May 17, at his home in Blue Ridge Summit, Penn. He was born on July 22, 1880, in North Grafton, Mass., son of the late Dr. Watson E. and Emma Pierce Rice. He graduated from M.I.T. in 1903 as an Electrical Engineer and practised mostly in New York City with the Pennsylvania Railroad. He later worked for the New York Edison and Consulting Engineers Firms. He retired 1933 and settled near Lewiston. In World War II he returned to engineering with the constructions of War Plants. At the close of the war he was sent by the State Department with a group of engineers to China and Formosa to assist the Chinese Nationalist Government. He had resided in Blue Ridge Summit since 1945. He is survived by two daughters, Miss Caroly Rice at home and Mrs. Herbert Chase, Alexandria, Va.

Our Happy Birthdays herald **Charles B. Cox**—November 4, 1881; **J. Russell Jones** III—November 15, 1880; **Robert J. King** III—November 29, 1881; Miss **Mary N. Philips** VII—October 17, 1876; **Jay B. Simon** III—October 29, 1879.—**John J. A. Nolan**, Secretary, Treasurer, 13 Linden Ave. Somerville, Mass. 02143

05

I had been expecting a note from **Fred Goldthwait** who has usually written me at once after he had received a word from me. None having come, I wondered if he was all right. So I telephoned from Cohasset on October 25. Ruth called him and he said he was fairly well and still drives his car, which is more than I can do. He had not written any Class news lately because no one has sent him anything, he said. He mentioned that our Class has now shrunken to 19 survivors.

Despite his reassuring report about his

health, he did not sound to me just the same as usual, so I am sending this in to contribute something to '05 notes. What I had sent him was a two-page article ("profile") in our local paper all about me. I had expected it would produce a reply but he did not mention it until I had first.

I hope **Herman Elsele** in Cleveland will read this and know I have not forgotten him. I have wanted to write him but my work as Honorary Town Engineer and Town Planner keeps me busy every minute.—**Fred W. Goldthwait**, Secretary, Box #231, Center Sandwich, N.H. 03227; **Gilbert S. Tower**, Assistant Secretary, 35 North Main St., Cohasset, Mass.

07

The granddaughter of the late **Hugh G. Pastoriza**, Sharon L. Pastoriza of California, has been admitted this fall as an M.I.T. freshperson.

George Appleton Griffin died on August 3 in Falmouth, Mass. He is survived by his wife Ellen and three children.

James M. Barker passed away on July 3 in Chicago, Ill. after a long illness. A Life Member of the M.I.T. Corporation for the past 34 years, at the age of 88 he was the oldest active member. Some excerpts from a letter by Howard Johnson to Members of the Corporation: Mr. Barker "held a special interest in language and in the development of museums and libraries. In 1970, the Institute dedicated the James Madison Barker Engineering Library in his honor. . . During his nearly forty years of service in the Institute's governing body, he served as a member or Chairman of 17 Visiting Committees and the Standing Committees on Membership and Develoment. . . After an initial career in structural engineering and construction engineering, including seven years on the teaching staff and faculty of M.I.T., he left the field of engineering for finance." For 40 years Mr. Barker worked for Sears Roebuck and Co., rising through a succession of appointments to become a member of the Board of Directors. He became Chairman of the Allstate Insurance Co., a Sears subsidiary, on his retirement in 1968. "His public service activities reflected his wide interests and his international reputation in the field of economic development. He was a Proprietor of the Boston Athenaeum, a Trustee of the Chicago Museum of Science and Industry, a Governing Life Member of the Art Institute of Chicago, a Life Trustee of Northwestern University and an Honorary Life Trustee of the Newberry Museum of Chicago. He served as a participant in economic missions to Iran in 1948-49; Chief of the Economic Mission to Turkey of the International Bank for Reconstruction and Development, 1949-51 and as a member of the Real Property Task Force of the Hoover Commission on Organization of the Executive Branch of the Government. He was awarded an honorary D.Sc. Degree by Middlebury College in 1939 and an LL.D. Degree by Westminster College in 1964." Mr. Barker is survived by his wife, Margaret, three sons, a daughter, several grandchildren and great-grandchildren.—M.L.

08

There are about 40 living out of 350 graduates. The oldest graduate is **Harry P. Sweeny** (91) a mining engineer of Rockland, Maine. His birthday is November 14, 1883.

After graduating from Yale in '05 with an A.B., he completed his education as a mining engineer with M.I.T. '08. His work as reported in the December edition of the 1970 *Review* took him to many states and many countries. He ends his report with the words "A rolling stone, but oh, what memories."

We are sorry to report the death of four of our classmates: **Alfred B. Babcock** C.E., 9 Morley Lane, Darien, Conn., died June 4, 1971. . . . **Frank E. Mott**, C.M., 75 Vermont St., W. Roxbury, Mass. . . . **George Schobinger**, C.E., 285 Swathmore Ave., Swathmore, Penn., died June 12, 1974. . . . **Ralph C. Walter Jr.**, E.E. 4209 Lawn Ave., Weston Springs, Ill., died February 5, 1973.

There are only two changes of address as reported by the Alumni: **Ygnacio S. Bonillas**, Gante 4-605, Apartado 2332, Exico of Mexico. . . . **W. Fred Dolke** 1550 No. Lake Dr., Chicago, Ill. 60610—**Joseph W. Wattles**, Acting Secretary, 500 So. Park Blvd., A64, Venice, Fla. 33595

09

It is with great pleasure we report that our classmate, **Mayo Dyer Hersey**, on October 17, at Brown University was awarded the gold Tribology Medal of 1974 for his "contributions to the engineering field". On August 16, Sir St. John Elstub, President of the Institution of Mechanical Engineers, wrote to Mayo from London that the award committee representing the Institution of Production Engineers, Royal Aeronautical Society, and Department of Industry, as well as the I.M.E., had chosen him for the award. The presentation was made by J. F. Barnes, the Scientific Attache of the British Embassy in Washington, D.C. The term "Tribology" has been in use only a few years and refers to the reduction of friction in machines. The award was not given to Mayo for any single scientific contribution but for an accumulation of research in tribology. It has been stated that Mayo is considered the world's foremost authority in this field. Mayo was a physicist at the National Bureau of Standards for 17 years. During World War I he worked in the development and practical use of aeronautic instruments. He also spent ten years with the Naval Experiment Station at Annapolis. During his teaching career he was an associate professor at M.I.T., part-time lecturer at Harvard, and is a visiting professor of research at Brown University.

Edward Merrill, who for a number of years was with the Washington Rapid Transit Co. and later President and General Manager of the Capitol Transit Co., wrote from Washington in reply to the notice of our 65th anniversary, "Regret that health conditions in my family do not permit absence from the city".

Just before preparing these notes we received the notice of the death of **Bradley (Brad) Dewey** on October 14 at his home Broad Lea, New London, N.H., at the age of 87. Brad, an outstanding member of the class, received many honors. He was a colonel in the Chemical Warfare Service in World War I and one of the founders of the well-known Dewey and Almy Chemical Co. of Cambridge, Mass. Further notes on his career and attainments will appear in the next issue of the *Review*.

A notice was also received of the death of **Arthur R. Knipp** on August 27 at Oakmont, Penn., at the age of 87. As members of Course VI Arthur and your secretary were well acquainted. His career was largely devoted to altruistic causes. Much of his life was spent teaching in China, particularly at Canton Christian College and at Lingnan University. During World War II, after the Japanese had overrun parts of China, he, his wife and daughter, were captured and held in a house at the top of one of the high hills of Hong Kong. Arthur's daughter narrowly escaped death when a Japanese shell came through a window at which she had been standing a moment before. At the conclusion of the war the family returned to the United States on the Gripsholm somewhat emaciated. At the first opportunity Arthur returned to Lingnan University. In 1972 we received a note from Kenneth S. Brock, Director of the Alumni Fund, saying that he had learned through an alumnus that Arthur was living at the Presbyterian Home in Oakmont, Penn., and continued to be active in the Shadyside Church, and maintained a keen interest in foreign affairs, particularly Chinese. Arthur did his undergraduate work at Johns Hopkins, then went to M.I.T., and received his Ph.D. from Harvard.

Austin B. Henderson, I, died March 25 in Swampscott, Mass., at the age of 88. He prepared for the Institute at Beverly High School. At the Institute he was a member of the Civil Engineering Society and also of its Executive Committee. His lifetime employment was with United Shoe Machinery of Beverly.—**Chester L. Dawes**, Secretary, Pierce Hall, Harvard University, Cambridge, Mass. 02138

11

From a letter by Elizabeth B. Tolman about her mother, **Ruth Dunbar** (Mrs. E. Mayo Tolman) who died on September 4: ". . . It was not easy for women at the turn of the century to pursue the kind of interests she had. We as members of her family, took great pride in her tenacity and contributions to society despite those formidable odds she must have faced."

Ruth Dunbar Tolman was born in Boston on October 29, 1885. She graduated in 1908 from Smith College, with a major in botany, did graduate work in bacteriology at the University of Chicago, and was one of the first women to be enrolled at M.I.T. She specialized in bacteriology and parasitology.

Ruth "felt deeply that women should have equal educational advantages with men. . . . She was deeply involved as a young woman in the 'votes for women' campaign. . . . All her life she scorned any arbitrary distinctions between men's work and women's work."

When she was 18, she and a friend founded the first summer camp for girls, Camp Kehonka on Lake Winnepesaukee—and after 70 years, it is still in operation. Ruth was co-founder of the first bacteriological laboratory in West Virginia. At the Boston University School of Medicine, she did research for Dr. David Belding for a book on clinical parasitology which was used as a textbook by the army during the Second World War. An account of her World War II

job in her own words from a letter: "When the war broke out and they asked to have women take men's jobs, I tried for one running a crane in the near-by Navy installation, but was told I was too old! So I became instead one of the three women who kept the Cohasset pumping station going. My shift (alone) from three to midnight. There was a big mixing-tank with an aerator on top that ice had to be knocked off many times during the winter, four electric pumps, three sand-filter beds, an auxiliary diesel pump, and 100 lb. bags of chemicals to lift and empty. I loved that job, especially washing the filter beds, and when it got so I could reverse everything and keep the pressures as steady as the other two men who had been there years, I was really happy."

Mark C. Kinney writes that "every Tech man should own a copy of *I Flew a Camel*, by Curtis Kinney. It costs $4.95 post paid from Ringwalts, P.O. Box 150, Mt. Vernon, Ohio 43050.

Frank G. Smith, 89, died Friday, June 28, 1974 at his home in the Arcadia Retirement Center, in Honolulu, Hawaii. He had "enjoyed 52 years of professional life with the American Brass Company of Waterbury, Conn., and was still in contact with most of his close associates in the Technical Department. With his many friends he exchanged news and jokes and mind-stretching mathematical puzzles, as well as birthday greetings and wishes for continued good health. He had 15 years of retired life in Honolulu where he took pleasure in Mother's garden and orchids, in his painting and silkscreen printing, and, of late, his activities at Arcadia."

Howard D. Williams said in a letter in June that he would soon become a great grandfather . . . from his letter: "I seem to be keeping 'above board' these days and each day seems filled with my 'labors of love'; the Salvation Army, on the boards of several colleges, etc. And I am at my office every day where my secretary takes care of my affairs."

Some excerpts from a letter from **Ralph E. Runels**: "A brief summary of my activities after leaving Tech in 1911. This stands out in my mind because on the same day as I graduated my wonderful grandfather, a sailor of whale ships, '49er in California, passed away.

"The customary 'getting started' jobs; laborer for New England Concrete Construction Co.; foreman for Aberthaw Construction Co.; Hydraulic Engineer for Electric Bond and Share Co., New York; Engineer for F. W. Dean Co., Boston; Lockwood Greene and Co., etc., etc., etc.

"Invited to join corporation with General Building Co. of Boston with H. Newton Marshall and Charles Potter. We at General Building Co. built widely over the East and as we also controlled the H. Newton Marshall Painting Co., we painted a great many structures including the Little Building in Boston and Keokuk Dam in the Midwest. Our construction activities included the building of the Pratt School of Naval Architecture for M.I.T. on Massachusetts Avenue. It is interesting to note that the widow of Admiral Pratt for whom the school was named insisted that the company that built the building should include as a member of the firm a Tech Graduate. I was that graduate.

"In 1921 I established the R. E. Runels Construction Co. of Lowell and under that name built a great many structures of all types over this part of the country. About 10 years ago I gave up active construction work and sold out my equipment to a local company here in Lowell. I maintain my office in the Chalifoux Building which we built in 1931 and still have my office at Room 416 where I'm still actively engaged in Consulting Engineering. I would be absolutely delighted if any member of the Class of 1911 could drop in and see me.

"One of my closest friends at M.I.T. is **Norman Lougee** who was in Course VI and by telephoning him this year I was delighted to talk to him and found he is still actively engaged as an Electrical Consultant in New York under the name of Manning and Lougee.

"You will be interested to know that when my brother Chester M. Runels, '15, passed on some years ago the Class insisted on making me an Honorary Member in the Class of 1915."—M.L.

(Please send Class Notes material to Marjorie at the *Review* . . . she is acting as Class Secretary for 1911.)

12

News continues to be scarce but here it is—written on a beautiful fall day with the foliage just starting to turn.

Harold Mitchell in Buffalo writes that he and Mildred are in generally good health but have taken no recent trips. Three of their six grandchildren are now married. Optimistically, they are hoping to attend our next reunion if one is held in 1977. . . . **John Barry** writes that he and Ruth are both well except for minor ailments. The work of caring for their large home had become such that they recently moved to an apartment near the village at 61 Highland Avenue, Cohasset, Mass. 02025. . . . **John Hall** of Allenhurst, N.J. sends an interesting note saying that he is getting along well. He points out that there are advantages to getting older. "History has certainly put on a big show in our time. Just to count the everyday things now that were not even thought of in 1912 except perhaps by a few who were listed as crackpots at the time. And there are so many things you don't want to do any more; places you enjoyed going to but once is enough; some people whom you once knew but are now glad you don't have to see any more. On the other hand, if you have done a good job or two, remembering them and perhaps looking at your footprints in the sands of time gives a special kind of personal enjoyment which these young people, now rattling around wondering where to go, must wait a long time to experience. Along these lines, I look back at my involvement in public health, where I spent much time and energy, with mixed emotions. Our successes were so quick and remarkable—as history goes—that it is a real question whether we did more harm than good. . . The excess of old folks (except you and me) is in itself a problem which eventually may sink us socially and damage us financially. But after all, it is these young people who must meet and solve all this. It is too late for us. Concluding, I have a devoted wife, a comfortable home, four normal grandchildren inspiring their way in a creditable fashion, so I am glad to help. Then I am financially sound, owe nobody, have enough to eat and am able to enjoy it. Last, but not least, is my friendly cat. Who could want more?"

A brief note from **George Brigham** enclosing photos of Michigan covered bridges which he has recently visited for the first time. They are now both well. . . . Col. **Harold Mabbott** who lives near me in Swarthmore, writes as follows: "I am glad to advise that all is well with me. I am most fortunate. I live alone here with occasional visits from my two daughters. In going over some old papers recently, I found a copy of the obituary of Malcolm Priest from a Pittsburgh newspaper dated Aug. 29, 1966, which was not published in the *Review* at the time. I roomed with "Mac" for three years while at Tech and had kept in touch with him and his family from that time on. Accordingly, I am sending you a brief summary of the obituary. Mac worked for the American Bridge Co. for most of his career first at Elmira, N.Y. Then he taught briefly at Purdue University in Indiana during World War I and returned to American Bridge in New York City where he worked on the design of both the Chrysler Building and Radio City Music Hall. He then transferred to the Pittsburgh, Penn. branch of the company until his retirement when he became a consultant for the U.S. Steel and the Pullman Standard Co. He was an expert on electric welding and published a book, *Welded Steel for Railroad Rolling Stock*. For many years he was an active member of the Unitarian-Universalist Church. . . .

In August, my daughter, Ruth, and I took a trip to Portugal, Spain and Mallorca, centering our activities from Estoril near Lisbon, Madrid and Palma on Mallorca Island. The weather was sunny throughout the trip but very comfortable. Everywhere we were most impressed by the good roads and heavy traffic, as well as by the large number of high-storied, modern hotels, apartments and condominiums, many of which are under construction. A high percentage of the latter are owned by Europeans from other countries who use them for pleasure from six to twelve months a year. The many ancient castles and cathedrals, up to 700 years old, were particularly impressive. I must not forget to mention the many old windmills, particularly on Mallorca. The terrain is very hilly and there are many cork, olive and almond trees with many cultivated open spaces. There is much swimming at beaches along the coast in both countries and daily distributions of fish by the fishermen.

Palma, on Mallorca Island, is a resort city with a population of 250,000 and growing rapidly. The downtown beach line resembles Miami and the suburban bay line is also expanding rapidly. There is also an unusually large downtown docking area with a yacht club and hundreds of sailing and motor craft used for pleasure, many from other countries, as well as fishing boats and large cruisers. In no other country I have visited, however, is the number of English speaking people so few. My wallet was stolen in Madrid and I had to wait several hours at the central police station to secure someone to whom I could report the loss in English.—**Ray E. Wilson**, Secretary, 304 Park Ave., Swarthmore, Penn. 19081

13

The activities of the secretarial staff of the

Class of 1913 have been somewhat curtailed the past few months. Your Secretary has had a few bouts with arthritis together with a sprained left leg. For the first time in many years "yours truly" was not physically able to attend the Alumni Offices Conference at M.I.T. Friday and Saturday, September 13 and 14, 1974. The Class of 1913 was ably represented by its President, **Henry O. Gildden** and his wife Jane, and also **Francis H. Achard**. From a letter from Henry and Jane: "Jane and I arrived at about three o'clock on the 13th at Hotel Sonesta, parked our car, and checked into our room overlooking the river toward Bunker Hill Monument and the Science Museum. It was terribly hot but the room air conditioner soon fixed that. There were a lot of M.I.T.-looking men in the lobby and corridors with their wives but Francis Achard was the only other '13er there. A strike of M.I.T. service personnel caused minor inconvenience. After visiting the President's house and garden, buses took us to Statler Hotel for dinner instead of Walker Memorial.

After the dinner Luis Ferre, Alumni President, welcomed the Alumni and introduced Howard Johnson, whose subject was "Perspective of 100 years", an outline history of the Alumni Association stressing it's support and loyalty to the Institute through good times and bad. There are now 55,000 members of the Alumni Association. Then Luis Ferre presented a citation to William Edgerly in appreciation of his work for the Institute as President of the Alumni Association and a bronze beaver to Don Severence.

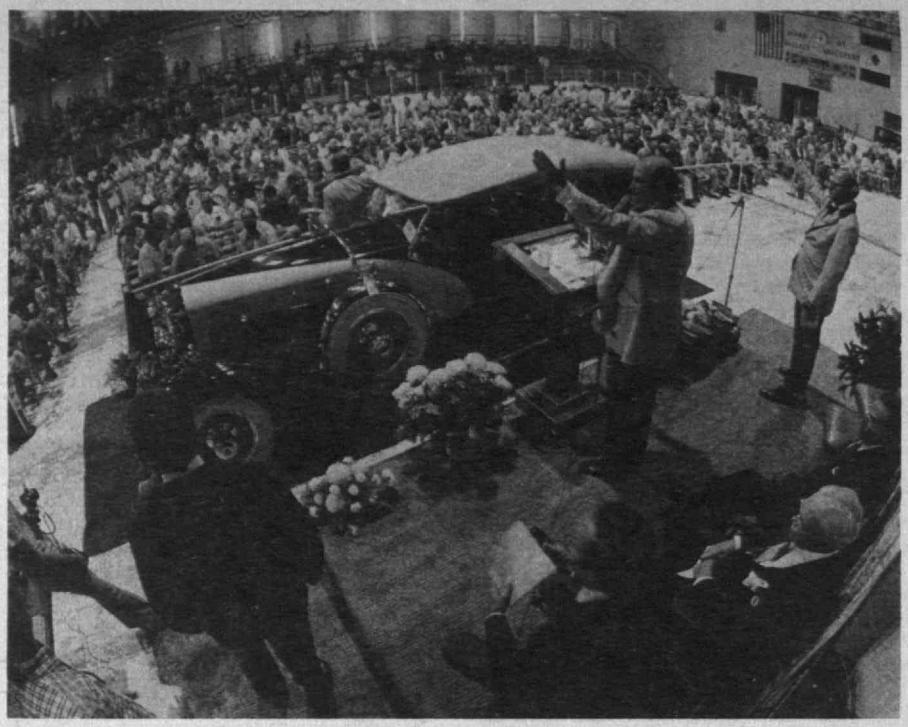
Constantine Simonides discussed the soon to be released survey of alumni feelings for M.I.T. and said M.I.T. is listening hard, indicating the high regard they hold for alumni views. It was found that courses classed under "Humanities" were favored two to one by the students, but we wonder if a cost study would show some of them not worth the expense involved.

The "best remembered" quote from Luis Ferre's talk was "we have learned how to communicate instantly around the world, but not how to communicate with each other." I think it was Edgerly who said, "true perspective of the Institute can be gained by comparing M.I.T. on Boylston Street with the present M.I.T." In his talk on "What it means to be an M.I.T. alumnus," Don Severence said, "M.I.T. has changed. More is expected from M.I.T. and M.I.T. expects more from us." From every speaker we heard the same pronouncement, that the tradition of faith in M.I.T. will continue strong.

Another note from **Henry O. Gildden**: "Principal activity since retirement—enjoying practice of my art, painting in watercolor and oil. Favorite subjects are nature in all its moods: sea, mountains, ships, wharves, country, New England, the prairies, California coast, Florida fishing boats. Having sold some paintings, I'm a professional and exhibit as such.

We have received a brochure from **Stanley Parker** of the so-called "Channing House", an 11-story building with 254 individual apartments including many restaurants, social and recreational facilities. All of those features are for the elderly residents of at least 62 years of age, with rentals depending on the size and location of the apartment.

We are very much pleased to receive a copy of the M.I.T. Alumni Fund 1974 Annual Report. A great credit for the success of the Fund should be given to the voluntary solicitors of Alumni of the whole country. . . . We were also pleased to receive copies of the reports of *Technology Review*. We are proud of the selections of subjects in science as well as humanities and other national subjects. We shall miss Margaret Kelly and we wish her continued success in her chosen field of endeavor. We have already established friendly relations with the new Alumni News Editor, Marjorie Lyon.



An auction of 17 antique and classic cars owned by George Wallace, '13, a retired Fitchburg industrialist and philanthropist, was held in Fitchburg, Mass. Total sales: $512,750.

George Wallace has made a wonderful contribution to M.I.T. by auctioning his several antique automobiles. From an article in the Sunday *Boston Globe* of August 11, 1974: George R. Wallace Jr., "put his collection of 17 antique and classic cars up for auction with the proceeds of more than $500,000 to go toward a new geophysical observatory at M.I.T. His prize car—a 1929 J. Duesenberg dual-cowl Phaeton—was sold to a Florida developer for $207,000, establishing a world's record for a purchase price of an antique or classic car.

"Wallace attended the auction, along with 150 prospective bidders and about 200 spectators, at the Wallace Civic Center, which he built for the city. He said he decided to auction the collection because 'when i die, where I'm going, they would all melt.' The 84-year-old paper mill magnate said he wanted to establish an observatory at M.I.T. in spite of his ill-fated academic career there. 'I had my distinction though,' he said. 'I didn't graduate, but I was one of the first to be kicked out. I liked to play the banjo and they did not appreciate it. It didn't hinder my career a bit.'

"The new observatory will detect earthquakes. Wallace previously donated an astrophysical observatory to M.I.T. The geophysical observatory will be able to detect an earthquake anywhere in the world, Wallace said."

Roz and "yours truly" enjoyed the fall dinner meeting of the Western Maine M.I.T. Club on October 15 at the Holiday Inn, Portland, Maine.

It was a real shock to me to receive a note from Phyllis Hopkins, **Philip V. Burt**'s daughter. Phil passed away July 30, 1974. We were elementary students at Canton, Mass. and in high school from September, 1904 until we both entered M.I.T. in the fall of 1909. We were very close friends over the years all of our lives up to the time of his death, and we quote his daughter's letter of October 21: "Dad was Manager of Babson Institute Dormitories for many years. Sometime around World War II, I think, or shortly after, he became Purchasing Agent at Wellesley College, a position he retained until the obligatory retirement age—I suppose 65, at which time he returned to Babson as Dining Hall Manager. He tried to retire yearly but they always talked him into going back for just one more year. . . . Dad finally retired—this time he made it stick—about ten years ago. He sold the house in Needham and built this house. While here on the Cape he was active in the Retired Men's Club in Hyannis, the Men's Club of the First Congregational Church of Yarmouth, and the Cracker Barrel Club. A year ago last February he had a heart attack and slight stroke. At that time I came here to live as he had been living alone. . . . In July the doctor suggested he go into the hospital for tests as the heart medication was upsetting him. He seemed fairly well on the day he went in, but grew rapidly worse and died a week later. My greatest consolation was that he did not have to go into a nursing home, as he dreaded that more than anything. . ."

Best wishes to all of our classmates from Roz and Phil Capen. Keep well.—**George Philip Capen**, Secretary and Treasurer; **Rozalind B. Capen**, Assistant Secretary,

Granite Point Road, Biddeford, Maine 04005

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Ray Aldrich had expected to come to our 60th last June, but got too crowded between a medical check-up and a cataract operation. He reported in October that the operation was not only a complete success, but also has given him a new and agreeably bright outlook on the world. . . . **Fred Karns** also had planned to come, but was prevented by a health problem. He wrote in August that he was feeling much better, and that Margaret was fine, and always ready for a trip. . . . To answer a question during the reunion, Mr. Knight, Secretary of the Alumni Association, had its records looked up, and found that 474 persons, including both graduates and non-graduates, were originally affiliated with the Class of 1914. The comparable total about two months before the reunion was 93. Questionnaires were sent in April and May to the 83 classmates who were either graduates or, if they were not, had contributed at least once to the Alumni Fund; 29 responses were received, including one from the wife of an ill classmate who died early in May.

Even now, I hope it's not too late to acknowledge with thanks the letters and notes, including many greetings and good wishes for the reunion, from **Henry Aldrich**, Pauline Baird (for Lyman), **Ros Barratt**, **Jerry Blakeley**, **Fred Dale**, **Skip Dawson**, **Ted Gazarian**, **Leicester Hamilton**, **Fred Karns**, **Walter Keith**, **Freeland Leslie**, **Ray MacCart**, **Leon Marsh**, **Harold Mayer**, **Roy Parsell**, **Jim Reber**, **Harold Wilkins** and **George Zimmele**. . . . New address: **Gabriel Harris**, 32 Conant Rd., North Quincy, Mass. 02171—**Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

We have lost another popular and active classmate. **Larry Bailey** died October 1 in Duxbury, Mass. He had been an active and generous supporter of all class and alumni activities and had attended all our Boston meetings and Five Year Reunions. We'll miss him. Larry had shortly before visited Doc Lewis in Plymouth. He was former head of Course X during our day. He received a Master's degree in mechanical engineering in 1916 and then went with F.J. Stokes Machine Company of Philadelphia, where he soon became Chief Engineer. He remained with the company for forty-two years until his retirement in 1958. His invention, design and development of powder metal presses was recognized by a Stevens Institute of Technology award in 1947 and by the Metal Powder Industries Federation in 1966, when he was honored as a Powder Metal Pioneer. He was also commended by the White House upon receipt of the Stevens Institute medal for outstanding achievement in the field of powder metallurgy. He also received patents for the development of tableting presses and high vacuum pumps. The famous "Life Saver" candies and many millions of aspirin and bufferin tablets are made on the machines Larry developed. His son, Robert E. Bailey, 1941, attends our Boston class meetings.

Larry Lander's wife, Fanny, died October 1, in Brookline, after a long illness. Many of the Boston crowd will remember the pleasant and enjoyable lunch she gave us in the garden of their Newton house way back during World War II. Our sympathy and deep feelings go to Larry in his sad loss.

Dick Bailey writes about himself: "Several years ago I legally turned over all my property to my nephew. He takes care of me excellently and prepares all my meals. I am beginning to show my age. I have trouble walking and have to use a cane. I spend nearly all my time in this old house where I live. For more then a hundred years it has been known as "Blue Ball Inn". I think of you often in relation to our annual class dinner at The Chemists Club in New York. I graduated from Williams College in 1910 in the Chemistry course and stayed on there for three years as an assistant in the chemistry lab, but, I was not on the faculty. Then I went to Tech for a graduate course in chemical engineering. It was there that I met you and our 1915 classmates. I always looked forward to those annual class meetings at The Chemists Club in New York. They were one of the things I loved most. As these meetings came to an end, I felt a touch of disappointment as well as old age. I enjoy receiving *Technology Review* and reading your class notes with the familiar "help Azel" appeal. You surely are doing a great job as Class Secretary. I am secretary of our 1910 Class at Williams, but with so few of us left, I do not write the way you do. I served several years in the army in World War I, in the Medical Corps. For three years I trained the soldiers how to wear their gas masks. I was discharged as a Captain and returned home after a three month vacation in France. Back in my home town, Oneida, New York, I went with the American Chemical Paint Co., who made materials to treat steel sheets so that paint would adhere better and protect the steel from rusting. Since I joined the company in 1940 with its eight salesmen, it now has 80 salesmen. For an old man, I really enjoy life. I have no ailments, nor aches and pains and feel much younger than I am! I always love to hear from you and really 'Help Azel'." A fine letter from a remarkable guy. With his consumption of Scotch and his stories, he was the life of our New York class parties.

Alton Cook wrote describing himself as an "old woof" in contrast to his former reputation of "old wolf" with an unprintable description of what this change had done to his propensities. He recovered easily from some minor surgery of an hour's duration and is now doing fine. . . . Harold Dodge, the hard working 1916 Secretary, wrote that his granddaughter from Wisconsin entered Wellesley this fall. He remarked about our tuition at Tech of $250—the highest, then, in the country. How times have changed. . . . A note from **Jim Tobey**: "I greatly enjoyed the eleven days at the Dartmouth Alumni College, the lectures and seminars on ecology. While there I met Sandy Brown, professor of physics at M.I.T. and his wife, who live in Lexington, where I used to drive the Royal Blue Line when in college." . . . From way out on Lake Powell, Utah, **Bob Welles** wrote "I am cruising this lake, 186 miles long, with my two daughters and a granddaughter. This is part of the Colorado River, dammed up in Glen Canyon. We travel in a houseboat, which is a shack on two pontoons, propelled by two outboard motors. The sky and the water are blue and the cliffs on both sides are red. My daughters do all the work. It's the "life of Riley" for me—" (Ah, me!) . . . The Boston Class Luncheon on October 18, will be reported next month. . . . All the best to you all and your families for a happy and healthy holiday season.—**Azel W. Mack**, 100 Memorial Drive 2-6A, Cambridge, Mass. 02142

16

Here we are again with our best wishes for a Merry Christmas and a Happy New Year as we look forward to our 59th reunion next June. Already we understand from Azel Mack, the friendly secretary of the Class of 1915, that they are hard at work on the de tails of their 60th Reunion. Last month we reported that Lois and **Charlie Lawrance** left our reunion early with a spare lobster for their son Dick (M.I.T.'40 and PhD'50) who attended our 50th in 1966 and was ill in a nursing home in Plymouth. We are very sorry to have to report Dick's death on July 26, a brilliant scientist in the field of electronics, a member of the famous electronics lab at Tech, one of the initial developers of Loran (long range navigation). Our deep sympathies to Lois and Charlie and members of the family.

Our faithful Assistant Secretary **Len Stone** and Dolly got off to their beloved Little Beaver Island in Lake Winnepesaukee in July, a bit later than usual but in September continued to report the "nicer living on the lake" than closer to the city. And Dolly noted that Len even "went places" in the lake area at the end of the summer—places that seemed to be no-no earlier. . . . Back in June an article in the *Hartford Courant* tells how our widely known Class Treasurer, **Francis Stern** was elected Honorary Chairman of the Board of Directors of Junior Achievement of Hartford. He has served as Vice President of Junior Achievement since 1960 and Director of the organization since its inception in 1951. As noted in the article, "He was also Director of the National Board from 1957 to 1969 and served on the National Board Executive Committee from 1964 to 1969. In 1956, Stern received Junior Achievement's 'Man of the Year' Award—the highest honor bestowed by the organization on business and industry leaders. Stern is the founder of Stern & Co., Inc. electrical appliance distributors, and served as President from 1922 until his retirement in 1953.". . . . **Paul Austin** of San Francisco has what we consider a real bit of unusual news. Last September Arthur G. McKee called him back to work in spite of his 80-plus years. Apparently the company moved from their five story brick office building to a brand new 3-storied building in San Mateo. "We are located up in the hills. The area is something like an industrial park, but there is nothing but office buildings instead of manufacturing plants and warehouses. Each building is at a different level with ample parking areas in between. McKee has lots of work, much of it is in the design of new types of copper smelting plants that eliminates the discharge of SO_2 gas to the atmosphere, to comply with environmental requirements." Be sure you take some time off fairly often, Paul! . . . Beatrice and **Walt Binger** returned in mid-August from a trip to Europe, a few days in Paris, and a fortnight in Italy on Lake Como, the fifth time in 10 years. Then they had a week with their daughter and son-in-law in Zermatt, which

skiers like Sibyl and Ralph Fletcher know all about. Then says Walt: "The son-in-law David Mitchell, with good climbing legs, had decided to climb the Matterhorn. He is 51 and the guide said he would not take him unless he had spent ten days climbing six to seven hours a day. This he did and two days after we left, roped to the guide, he truly reached the top of the Matterhorn".... Early this summer wehad word from the widows of two of our famous classmates, Pearl (Mrs. Robert E.) Wilson of Washington and Helen (Mrs. William B.) Leach of Austin. Pearl returned in June after an extensive cruise through the Mediterranean, "a very nice one" but she's "now content" and does not "plan to go on any more". A fall prevented her from taking a planned motor trip to Wooster to celebrate the 60th Reunion of Bob's class ('14). Helen Leach returned early in July from a "two weeks trip to Alaska (as far as Fairbanks) with the English Speaking Union—24 members—"and nice people. I went with Mrs. Donald James of Austin"—husband M.I.T '21. Says Alaska and Guatemala appeared to be the two most promising travel spots this year.... From Shreveport, **Art Shuey** wrote in July: "A quiet summer so far. We went to a meeting of Astronomical Society of Pacific in Bishop, Cal., the site of the Owen's Valley Radio Observatory of Cal Tech. Very disappointing to one used to optical telescopes, even knowing that their instruments worked day and night, but showed only lines. However, we flew to Marble, Colo. and had two weeks of excellent trout fishing."

Gyps and **Cy Guething** had their two weeks up in Leland, Mich. where Cy says, "It is beautiful country and they have everything except salt water and fresh shell fish." There, he talked about getting back to his farm, where they had picked about half their pole beans in August and were enjoying the earliest tomatoes. Says his gardener "likes the green ones fried, so they don't all mature." . . . As for traveling, the **George Mavericks** report a 10-day visit to Mexico and three weeks in San Antonio. George notes, "Mexico didn't treat us well as it has on many trips. Mexico City's altitude was a bit too much for Ruth and I got 'tourista' in Guadalajara. Inflation in Mexico was officially two and a half times that of last year but some estimates say the poorest people had their prices doubled. We had a feeling of social unrest and were glad to get back. After a month of motels and hotels and restaurants, our apartment in Charlottesville seems positively heavenly!" . . . We always have some most interesting material to pass along when **Dina Coleman** writes. Here's what he says this time: "Being retired from all business enterprises, All I do now is sit around and stew about what's going on. When banks take 10 per cent off the top and charge 12 per cent on the balance for construction money, I just don't see how the house builders are going to keep it up much longer. My architect son has a six million dollar project stopped at the third floor because the promoter ran out of money. The demand for money is still tremendous, however, for banks are paying 12½ per cent for C.D.'s. Sooner or later something is going to bust. Of course, Transylvania University, the Philharmonic, the Cerebral Palsy School and the Opera House rejuvenation project keep the telephone ringing. With all the 'do-good' enterprises I have fooled with during my lifetime, this Cerebral Palsy School is the absolute tops. When they take a helpless brain-damaged child from a basket and in two or three years have him walking, talking and able to make his own way in the public school system, the economical and emotional impact is fantastic. During my year and a half as Chairman of the Board of the Governor's Council on Developmental Disabilities I learned two things. One, that about 10 per cent of our people are disabled in one way or another; and two, the Government's way of attacking the problem will never get the job done. They waste entirely too much money on staff. I don't know how people like me can do anything about it, so I quit."... And **Frank Holmes**, after a month's stay on Treasure Island, wrote last spring: "Weather excellent but the "red tide" killed thousands of fish and spoiled all fishing and bathing. Looking forward to spending the summer at our summer home in Fitzwilliam, N.H."... **Nat Warshaw** sends us a view from Weymouthport, a waterfront condominium community, located on Hingham Bay, where he lives. He says, "How do you like the view? The floor above the pool has a fine putting green just completed and under that is a recreation area with sauna baths, game room, hobby shop, TV room, kitchen and large meeting room. This will all be finished shortly."... Just before reunion time **Harold Mills** of Mountain Lakes wrote from Nantasket: "Well, we are up here again, and the lobsters and clams taste as good as ever. Doing small jobs, washers on faucets, light switches, poor electric plugs, etc. Fair weather but cold: better than hot; very high tide at new moon. Much winter vandalism around here."

Theron Curtis in East Falmouth commented, "Very few at the reunion—sort of sad to see our numbers decreasing each year, but this is life. We are lucky to be so well—go swimming most every day and work around the place for exercise." . . . **Frank Upton** of Lanham, Md., noted last May: "We have sold our home and are preparing to move to a new one. Children and grandchildren are coming and going and relieving us of some of our over 50-year accumulation of stuff; some, just junk." . . . Late in June, **Rudi Gruber** said he had just returned from Germany where he celebrated his 83rd birthday with his brother.... We must report something delightful and so thoroughly appreciated that happened to us in September. Frances and **Paul Duff** came all the way to Mountain Lakes just to visit us "for a brief non-fatiguing time", as Paul said, in view of our four years of missing reunions. We discussed reunions and, like most grandparents, what the children and their families are doing, and what people today call 'progress in education'. Speaking of 1916, Paul said in our later years we get to know many classmates much better than we ever did on Boylston Street. This year's reunion, he said, was a little small but it was as enthusiastic as usual.... **Shatswell Ober** of Arlington indicates that any lack of news from him may well imply that he is not doing anything exciting beyond raking leaves and mowing his lawn at appropriate seasons.

Again we appreciate the good response we have been getting from our periodic letters asking for bits of news on who, what and where as well as bits of seasoned philosophy. It all helps to keep your secretaries from getting just plain lazy. Items from the **Pattens**, **Ted Parsons** and **"J. H." Murdough** will be reported next time. —**Harold F. Dodge**, Secretary, 96 Briarcliff Rd., Mountain Lakes, N.J. 07046; **Leonard Stone**, Assistant Secretary, 34-16 85th St., Jackson Heights, N.Y. 11371

17

The weather and the spectacular fall coloring could not have been better for our 57th Reunion at Northfield. After a preregistering of 43 we actually numbered 35 as shown in the listing herewith. We were honored and happy to have with us Honorary Members President Emeritus Jay Stratton and Mrs. Stratton and Phyl and Don Severance. It was good to have two widows, Betty Hulburd and Dorothy Ross, with us. Ruth Dennen had been expected but could not come at the last moment. The return of 99 cards from an active class membership of 179 indicates the genuine interest in the Class and the Institute and is appreciated. Succeeding notes will relate more about those cards. Those attending were, the **Bob Erbs**, **Will Neubergs**, **Dick Loengards**, **Phil Cristals**, **Stan Lanes**, **Brick Dunhams**, **Bill Hunters**, **Al Lunns**, **Walt Beadles**, **Frank Butterworths**, **Stan Dunnings**, **Kenla Lanes**, and individuals **George Henderson**, **Jesse Rogers**, **Miles Demond**, **John DeBell** and **Dad Wenzell**.

Monday afternoon Susan Lunn again graciously gave us a piano recital that was thoroughly enjoyed and appreciated. The social hour developed much conversation and was again enlivened by Frank and Helen Butterworth at the piano. The reunion banquet was held that night. There were greetings from Jay stratton and a report by Al Lunn on activities in connection with the Aldrin Scholarship Fund. Al and Stan Dunning had recently had an interesting lunch with Aldrin Scholar Owen Knox and the Associate Director of the Student Financial Aid Office. Consequently the following letter addressed, "To the Class of 1917" was received and read:

"I wish to express my sincere appreciation to the members of the Class of 1917 for your generous financial assistance so vital to the continuance of my education at M.I.T. Presently I am a third-year undergraduate double majoring in Astronautical Engineering and Biology. My specific professional objective resides in the field of aerospace medicine. Of course, a precursor to the attainment of this goal is attendance at a qualified medical school. Realistically, a spirit of cautious optimism pervades my aspirations since I have chosen to follow a path which few have trod.

"During the summer of 1974, I was fortunate to obtain employment with Pratt & Whitney Aircraft Corp. in East Hartford, Conn. I was assigned to the Experimental Test Division where we performed component and full-scale engine testing to determine fatigue stress, altitude performance, and Mach number range on various engines such as the F-100, JT9D and JT10D. The remainder of the summer I donated 250 hours as a volunteer to the surgical unit of the Mercy Hospital in Portland, Maine. This was a truly fascinating educational and personal experience. Both the surgeons and the nurses were instrumental in providing me with scientific techniques, procedures, and post-operative patient care.

"For the present, I am actively engaged in

an orthopedic research project at the Massachusetts General Hospital under the aegis of Dr. Michael Ehrlich, Chief of Pediatric Orthopedics. We are investigating, im vivo, the metabolic effects of substrates on experimental osteoarthritis in rabbits. I have a unique opportunity to apply many of the surgical techniques and procedures gleaned during the summer to the project which requires performing surgical lesions to simulate an osteo-arthritic condition. The time commitment is 15-20 hours per week for which I will receive course credit via M.I.T.'s Undergraduate Research Opportunity Program (UROP). In addition, my course load this term is 52 units, or translated, 25 hours of classes per week.

"Supplemental to my academic activities, I find refreshment in studying classical and contemporary guitar, tennis, and many aquatic sports such as scuba diving which helps retain the strong ties that I have with my native state of Maine. It is my fervent desire that this brief synopsis will provide a personal revelation of the efforts to which you have chosen to lend your support."

The income from our $100,000 scholarship fund amounts to between $5—$6,000 annually. Of this, $2,500 goes to Knox with the balance going to other students in Aeronautics and Astronautics. So there was a report from the Student Aid Office listing the names and interesting information of eight other students, including two women, from seven states and Puerto Rico who had received fund aid. The report was read including appreciative remarks for the Fund and the personal interest by the Class. All this information was enthusiastically received with a just feeling of pride in what has been accomplished in this ongoing program.

After dinner **Ken Lane** was asked to relate some of his recollections of his close association with Charles Lindbergh. Most of us knew that Ken, himself, had poured 552 gallons of gasoline, from 5 gallon cans into the Spirit of St. Louis but now, for the first time, we learned of Ken's being Lindbergh's right-hand man and confidant during the final preparation and take off. Ken was the Wright Aeronautical Corp. representative at the field where the three contestants were preparing for the daring flight and all machines had Wright engines. It was a most interesting story.

Helen and **Stan Lane** have traveled far and wide over the years and always with a movie camera. We have been favored several times with excellent travelogs. This time it was the 1958 trip to Hawaii interestingly narrated by Stan. With this showing the evening ended.

Tuesday was a day to enjoy the color and tours. After lunch pictures were taken. Again the social hour was fun. With the Butterworths dueting at the piano some dancing took place. After dinner the annual business meeting took place. Treasurer Lane's report indicated that the Class is still solvent and there is no need for a dues payment call yet.

President Lunn told of a program which is underway to raise $210,000 for renovating and extending the M.I.T. sailing pavilion, and for renewing and enlarging the fleet. He called attention to the excellent folder which was at each table entitled "Sailing at M.I.T.". He then revealed that the committee of sailing enthusiasts promoting the program have named **Walter C. Wood** as Honorary Chairman of their committee in recognition of Jack's services to M.I.T. as well as his standing as "Father" of intercollegiate sailing. Al then presented the proposal that the Class support the program by designating our gifts to the Alumni Fund for the next three years to be for the sailing pavilion in the amount of $25,000. This would be our recognition of Classmate Jack's services. It was pointed out that if the Class maintains its usual rate of giving, our goal should be reached. Immediately a motion was unanimously passed that we would support the program as outlined. It was emphasized that the program is not a 1917 project.

Jack Wood, '17

A few years ago Elizabeth and **Heinie Gartner** donated an authenicated Julia Grant desk to Mrs. John Kennedy's White House furnishings. This spring Elizabeth, anticipating a Washington visit, asked Senator Kennedy if he could arrange for her to see the desk. All went well, she had a special tour, saw the desk in the Treaty Room and other things not usually open to the public. . . . Evelyn and **Ray Blanchard** are living at the Beverly Manor, Exeter, N.H. 03833 where they are happily located not far from his boyhood area. The Manor is close to the Exeter Inn and has complete facilities. . . . **Nelson Chase**, creator of the Rogers Building painting given by our class widows at the time of our 50th, and two significant murals in the Boston Harvard Club, is still at it. His most recent commission is a four by four foot oil of a Belmont, Mass. old time engine, circa 1900, at the station, all with a bird's eye view of the community.

On October 12 seventeeners **Lunns**, **Dunhams**, **Dunnings** and **Jesse Rogers** joined the 1918 one-day reunion at Endicott House. The guest speaker was Prof. Harold Edgerton who, as always, gave a most interesting illustrated talk on the stroboscope and sonar usages of which no one knows more. . . . **Tom Ryan** writes, "I was delighted to see in the *Review*, the presentation of the jacket to Arthur Fiedler. One of the great pleasures my wife and I have is the Sunday evening Boston Pops. To an old Concord boy they bring a bit of Huntington Avenue nostalgia to the banks of the Mississippi."

We extend our sympathy to **Cy Medding** on the death of his wife Elizabeth. . . . Regretfully the deaths are recorded of **Charles E. Atkinson** on May 20, 1974 at Newport News, Va., **Max J. Mackler** on September 12, 1974 at St. Petersburg, Fla., and **Arthur H. Paul** on March 16, 1974 at Morrisville, Penn.—**Stanley C. Dunning**, Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard**, Assistant Secretary, 21 East 87th St. New York, N.Y. 10028

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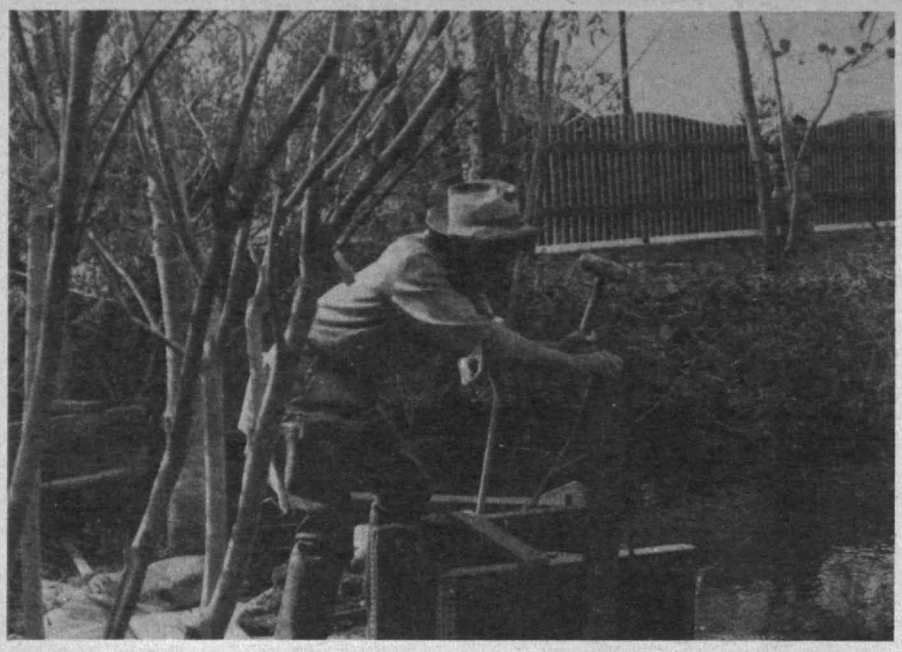
It was a most happy and auspicious occasion for all of us who participated in our fifth mini-reunion at Endicott House on October 12. Our attendance was not quite up to normal because of conflicts due to the long week-end holiday and some who had to stay home because of illness—and we missed them. The day was perfect—the illustrated talk by "Doc" Edgerton on "Probing under the Ocean with the Stroboscope" was particularly absorbing to all of us. In addition we were given a further treat by Vice President Constantine Simonides with his report on the recent M.I.T. Alumni Survey. The grounds at Endicott were at their glorious best—an added enjoyable dividend was a guided tour of the greenhouse. The program intrigued us all most pleasantly—but the real happiness for everyone was the opportunity to renew social contacts with each other—all the more precious to us with the passage of time. In addition the mingling of the classes of '17 and '19 and '18 added to the enjoyment of the day.

The '18 attendees were Frances and **Pete Harrall**, Elizabeth and **Julie Howe**, **Julian Avery**, Gladys and **Leonard Levine**, Marion and **Herb McNary**, Mildred and **Charlie Watt**, Hazel and **Sax Fletcher**, Elinor and **John Kilduff**, **Pete Strang**, Winfred and **Sumner Wiley**, and Selma and **Max Seltzer**. Representing '19 were Jessie Rogers, Jeannette and Stan Dunning, Sue and Al Lunn, and Edna and Brick Dunham, while Lida and Ben Bristol did the honors for '19. In addition we were very happy to have Azel Mack, '15, join us on this festive occasion, as well as Joan and Dick Knight, '47, and Joe Martori of the Alumni office.

Many regrets came to me from classmates unable to make the trip to Dedham some of which I record in this paragraph. **Warren Scott** was on a trip to South America. **John Norton** was in Europe. **Ted Braaten** was in Washington—he reports a marvelous boat trip in June from Bergen, Norway, around N. Cape to Kurkines and return stopping at towns along the way—most of which have no other means of communication. Gorgeous scenery all the way and midnight sun most of the way. . . . **Charlie Tavener** reported that he was moving to a new house he had just purchased on mini-reunion day. . . . Regrets came to me from **Al Walker**, **Don Goss**, **Bill Collins**, **Jim Bugbee**, **George Sackett**, **Clarence Fuller** amongst others who would have joined us but for their immobility or that of some member of their family.

The enclosed note from **Sid Blaisdell** tells its own story. Next year we hope to have our day at Endicott House earlier in the year so you can be with us. "We are very sorry that we will be unable to attend the fifth 1918



John Abrams, '18, and his Mini-Hydroelectric Generating Plant.

mini-reunion. The last two summers we have spent in the wooded hills of western Rhode Island on the shores of Quidnick Reservoir. Around the middle of September the lovely little cottage on the lake gets rather cool, so we pack up, put the sailing dinghy in storage and start our trip back to Florida with the help of the Auto train. We find this train to be very helpful but since reservations have to be made long in advance they cannot readily be changed for even such an advent as the 1918 mini-reunion. Perhaps we can make plans for a de layed start some year and have the pleasure of attending a mini-reunion, in the mean time we hope you have a good crowd and a fine time."

In early September I received the enclosed letter from **Tom Brosnahan**: "On Friday, October 11, we shall start a 45 day cruise around South America on the Gripsholm of the Swedish American Line. The ship will stop briefly at Port Everglades, Florida, to pick up additional passengers. We shall then sail through the Caribbean Sea, the Panama Canal, down the West Coast of South America and up the East Coast after passing through the Strait of Magellan. Stops of a day or two will be made at San Blas Islands, Balboa, Toboga, Callao, Peru, Valparaiso, Puerto Montt, Punta Arenas, Buenos Aires, Santos, Rio de Janeiro, Bahia, Barbados and St. Thomas in the Virgin Islands. Please give my kindest regards and best wishes for continued good health to all M.I.T. men assembled at that spirited, festive and interesting occasion at Endicott House on Oct. 12."

On October 10 I received news from Jim Phinney—Secretary of the M.I.T. Club of N.Y., stating Tom was in a hospital. I called Tom at the hospital who stated he was in for observation. More recently I learned sorrowfully that he is seriously ill.

Thanks to **Len Levine** we have this news from **Nat Krass**. "It is always good to hear from you. I am feeling fine outside of my eyes. I have completely lost my reading eyesight but am able to get around. Therefore, I do not do any travelling but stay pretty close to home. My children are all doing fine. My daughter, Stephanie, lives in Pittsburgh. She is married to a city planner there and they have two children, six and four. My son, Jonathan, is a stock broker out in Palo Alto, California, and he, too, is doing well. I have lots to be thankful for."

Carlyle Fiske writes a letter which is reprinted herewith. I understand of course that not all of us are equally enthused about reunions—on the whole, however, most of you who have enjoyed them very much. I hope, Carlyle, that you can take the next opportunity to join us—and see if the lightning of good fellowship will strike you as it has many of us with the dividend of much pleasure.

"This is a very late reply to your letter of October 1, 1974, at the time I was at the Cape and it was impossible for me to attend the mini-reunion on the 12th. Aside from that, to be brutally frank, I do not like reunions. I had a rather unpleasant experience some years ago at such a function, not a M.I.T. one to be sure, but it has soured me I guess. I am a great believer in letting bygones be bygones, but I do appreciate many people get a great deal of pleasure out of such functions. The most intimate friends I had in my college days have, for the most part, passed into the great beyond and I don't like to be reminded that time is running out for me.

"A year ago this time both Mrs. Fiske and I were seriously ill with pneumonia and neither of us has sprung back to where we were before the illness, energywise. We spend the greater part of the year here at Cape Cod, spending only the real winter months in Winchester. I am a new convert to the Cape, being a Maine enthusiast for over 50 years, but Mrs. Fiske is right at home here on the Cape as her great grandfather was the original owner of the land of what is now Chatham. Maine is too far away now and too rugged a climate for our years. It is lovely in summer in Maine, but the late fall is too cool for us. It was pleasant to hear from you and I extend my best wishes for the coming holiday season to you and all the other class of '18 chaps that may be in the area."

Most faithful **John Abrams** wrote from Bishop, California of his problems with water rights and with predatory developers. Included in his four page "Friendly Report to the People of West Bishop—One Man's View on Planned Unit Development and Related Issues"—is the following item about a Mini-Hydroelectric Generating Plant: "Last fall I achieved an eight year goal: a water wheel on an environmentally protected shady dell on South Indian Creek. The energy will be from an antique paddlewheel, 4.5 ft. in diameter and 2.5 ft. wide, now running at 16-30 r.p.m. Its calculated capacity is 0.01 h.p. or 7-8 watts! The angle-iron structure, supporting a train of gear-belts and pulleys, is about 1 ft. square and 3.5 ft. high. It awaits special castings from back east.

"To achieve velocity I raised the level of the mill pond 1.5 ft. by erecting a stabilized embankment or 'dam' with several control gates and a headrace. The backwaters reached upstream, similar to two on my property. By backbreaking removal of sand and silt I've created the best erosion-control and flood-dissipating system on Indian Creek. The detritus comes from eroded upstream channels. That damsite is the 'eye of the tornado'."

John concludes with Friend Max: "No proliferations, just bon jour et adieu—I'm packing my Scout for my hegira to the wilds of Montana. Have made my peace with all levels of my better-government pursuits—Gov. Reagan honored us here—Mr. Liverman, et al, came with him and stayed over to visit our sylvan setting for paddle wheel. Enclosures give you an inkling of what my last battles have taken—maybe I can give some interesting dialogues I've had in forest fastnesses with wildlife like a mama badger and pup, or a beaver, or sly fox, or a scared antelope! Wish it could be vis-a-vis with a grand like M. Seltzer!"

It is with great sadness and with a sense of a personal loss of a true friend that I note the death of **Al Grossman**. He had attended the 1974 A.O.C. meeting only two days before his passing. Len Levine reports: "Al was a modest, soft spoken, gentle, friendly, quiet person who was always more interested in listening to others than talking about himself. He studied mining engineering but spent most of his adult life in the rubber business. He was a collector of rare specimens of minerals. Al was president of the Stedfast Rubber Co., Inc., of the U.S.A. and Canada. He served in the Army of World War I. Al and Stella rarely missed a 1918 reunion. He leaves his wife Stella, two daughters and four grandchildren and a very large circle of friends. Julie Howe and Len Levine represented the Class of 1918 at the funeral service."

The Alumni Office reports the death of **John A. Steere** on June 24, 1974 . . . and Leland Estes records the passing of his father **Frederich M. Estes**, on August 24, 1974.—**Max Seltzer**, Secretary, 60 Longwood Ave., Bookline, Mass. 02146; **Leonard Levine**, Assistant Secretary, 509 Washington Street, Brookline, Mass. 02146

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The *New York Times* and *Time* Magazine had write-ups about the death of our classmate **Philip L. Rhodes**, who we had the pleasure of being with at our 55th in June. Phil was 79 and passed away on August 30, 1974 in New Rochelle, N.Y. *Time* says "Died.

Philip L. Rhodes, prolific naval architect whose Manhattan firm laid down lines for 700 vessels ranging from mine layers to troopships during World War II, but was best known for his designs of sail boats, among them the popular 11½-ft. Penguin dinghy, Bounty II, one of the first successful fiberglass ocean racers, and the twelve-meter sloop, Weatherly, winner of the 1962 American Cup races."

A letter from Grace Smith from Lottsburg, Va. announced the passing of her husband **Edgar R. Smith**, our classmate, on September 18 in a hospital in Richmond, Va. where he had been for eleven weeks. Reyn was 77 and had suffered from hip, then spine cancer. He had a Ph.D. in chemistry from M.I.T., taught Physical Chemistry at L.S.U. in Baton Rouge, Louisiana, and then spent his entire career up to retirement with the U.S. Bureau of Standards where he became their Chief Physical Chemist. He retired at 65 to a farm on the Potomac River near Chesapeake Bay at Lottsburg, Va.

The Institute Alumni Records informs us of the passing of **Ralston B. Smyth** on January 12, 1974 at West Brewster, Mass.

Royden L. Burbank sent me a copy of two books on astronomy which both he and I recommend as very interesting reading—*Red Giants and White Dwarfs* by Robert Jastrow and *Beyond the Observatory* by Harlow Shapley.

George Michelson dropped me a note on Sept. 3 saying "All's well here. Trust same is true of you. Warm regards."

Your secretary got back to Florida in October after a nice summer in Maine, Massachusetts, New York, Ohio, Indiana, and Maryland—**E. R. Smoley**, Secretary, 50 East Rd., 11E, Delray Beach, Fla. 33444

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Plans for our 55th Reunion, to take place on campus grounds Friday, June 6, and Saturday, June 7, are pretty well along and by the time you read these notes you will probably have received our first Reunion letter with further details. This is an auspicious year to be in Boston because of the 200th year observances, so we are expecting a maximum attendance and we urge you to make your plans early. It should be a happy occasion.

A card from Lois and **George Des Marais** tells of being stranded on the S.S. France three miles from the dock at Le Havre thus delaying their arrival in Paris which they found enjoyable. From there they went on to London before returning to their home in East Orange. . . . Florence and **Lee Thomas** had also been planning a trip on the France which, of course, was cancelled. However, undaunted, they are off to Munich, Budapest, Bucharest and Vienna. More power to them! . . . **"Count" Dumas**, who annually escapes the rigors of his Quebec homeland, in Cuernavaca, Mexico for the winter months, writes enthusiastically about the good times he and Evangeline enjoy at the M.I.T. Fiesta in Mexico City. He urges classmates to attend the Fiesta which is in mid-March, and says that they will enjoy every minute of this well planned and highly successful annual event. Better keep it in mind. It should make a worthy opener for our 55th.

Our illustrious classmate, **Carl Soderburg**, has been elected to the National Academy of Engineering, "for leadership in turbine design and innovation in engineering education" in which he served M.I.T. with distinction for many years. Congratulations, Carl. . . . A welcome note from **Frank Maconi**, of 33 Bonnydale Road, Leominster, Mass., tells of his most successful sponsorship of Rotary Night at the "Pops". While living in Wellesley, Frank was the guiding spirit of what has now become an annual event of the combined clubs of Wellesley, Natick, Newton and Weston until now, after five years, the group numbers over 1600 members coming from a 65 mile radius. Frank tells of another annual event on his part and that of his wife, Kay, whereby they go off to northern Maine in search of antiques for his "Country Store", for which he has been collecting for 35 years. Classmates in the vicinity of Leominster would do well to visit Frank's unique establishment there.

Attendance at the Alumni Officers Conference in Cambridge was enhanced by the presence of Betty and **Norrie Abbott** and **Perk Bugbee**, made doubly agreeable by the noteworthy fact that no less than two of our classmates were awarded the Bronze Beaver for distinguished service to the Alumni Association. . . . **George Morgan** of Texas was present at the Conference (and looking hale and hearty we are pleased to say) to accept the award "for his many years of devoted service as Honorary Secretary, Educational Council Regional Chairman, Club Director, and Club President, which exemplify the highest qualities of local leadership. Strong advocate and friendly critic, he is Mr. M.I.T. of Beaumont". . . . For reasons noted above, **Lee Thomas** was unable to be present to accept the award, much to our regret. Lee's citations reads, "For more than five decades, commitment and dependability have accented his outstanding service to the Institute in local, regional and national activities. A Charter Member of the Philadelphia Area Fund Council, a member of the Corporation Development Committee and the Visiting Committee for the Medical Department, are only a few of the undertakings he has successfully assumed for M.I.T."

We are proud of these men, and of **Ed Ryer**, who was previously awarded this prestigious honor, for contributing to the lustre of our illustrious class. . . . See you at the 55th!—**Harold Bugbee**, Secretary, 21 Everell Road, Winchester, Mass., 01890

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Over the years it has been interesting to learn that children of our classmates, and now grandchildren, are going to M.I.T. A news release just in from Cambridge lists two entering freshman: Kenneth Kraus of Little Neck, N.Y. whose grandparents are Elma and **John Mattson** and Ann Salyard of Los Angeles, Calif. whose grandparents are Elizabeth and **John Barriger**. Congratulations to both of them for picking a wonderful school.

A most interesting letter came in from **Bob Haskel** which explained why he disappeared while **Irv Jacobson**'s back was turned at the Pops Concert last June. "I had requested a center table but when Laura and I found ourselves right under Arthur Fiedler's podium we got the table changed to one farther back." Bob went on to tell that he had been bothered by angina for the past year but that new medicine was "helping to clear out the boiler scale from my tubes and the steam is circulating better now." Bob is still working for the company he founded, Standard Chemicals, and has no intention of retiring. He and Laura travel occasionally and recently took a cruise to Bermuda. Bob strongly urges classmates to visit M.I.T.'s new Historical Collections Museum at 265 Massachusetts Ave. which was described on Page 77 of the May 1974 *Technology Review*. The museum is asking alumni to contribute or loan M.I.T. mugs, plates, and old pictures to add to their collection. Bob found himself in several of the old pictures. The Haskels spent week-ends and vacation at their summer place in Dennisport on Cape Cod.

The Cape Cod '21ers continue to be an active group and reports have come in from both **Bob Miller** and **George Chutter**. Bob and Helen Miller returned to the Cape from their home in Maryland in late summer and on the way had lunch with Elizabeth and **Al Fletcher** at Leisure World in New Jersey. The Millers got a guided tour of the community and said it resembles their Rossmoor in many respects. . . . **Al Fletcher** spent his career in the public health field in local and state governments. . . . On September 5 the first M.I.T. fall luncheon was held at the Cove Motel in Orleans and the Class had a mini-reunion. Attending were **George Chutter**, **Bob Miller**, **Austin Kirkpatrick**, **Don McGuire**, **Sam Lunden** and **Whitney Wetherell**, plus 8 more from other classes. After luncheon they adjourned to the Yacht Club for the first weekly meeting of the Orleans Coffee Club. This group discusses the affairs of the nation with a lot of jest mingled with the serious. The club's motto is "Often wrong but never uncertain". . . . **George Chutter** reports that with the arrival of Labor Day the winds have swept the Cape free of tourists and he can now drive again without playing "wrinkle fender". The Chutters were planning a fall trip to Grand Rapids and Cincinnati to see their grandchildren. . . . Now that the class picture project is completed, **Bob Miller** is planning to assemble all the pictures he has of the 50th Reunion in an album to be available for our 55th reunion.

We are grateful to Emma Lloyd for a report on the Alumni Officers Conference held in September. Attending from our class were **Ed Dube**, **George Chutter**, Leila and **Sam Lunden**, **Arnold Rood** and Emma and **Al Lloyd**. The conference was somewhat inconvenienced by a strike of M.I.T. service personnel so that the Friday night dinner had to be transferred from Walker Memorial to the Statler and the Saturday luncheon was a box lunch. However we are informed the conference ran smoothly and was a worthwhile affair.

A letter from **Robert Worsencroft** of Madison, Wisc. tells of his retirement five years ago from the University of Wisconsin where he was Professor of Engineering Graphics. Your Secretary remembers Bob from Brockton High School days. The Worsencrofts were planning to move permanently to Sun City, Arizona this fall after having been winter residents there for several years. Bob notes that he reads about so many classmates in Florida that he wants to put in a good word for Arizona as a desirable living place.

Sadly we record the death on August 13, 1974 of **A. T. Eric Smith** of Montreal, Canada after several operations for cancer. Eric had

many friends in the class, came to our 50th reunion, and was a loyal alumnus of M.I.T. He entered M.I.T. in his Junior Year after getting a B.A. degree in 1918 from the University of Saskatchewan. During his business career he worked for Canadian Industries, LTD and Fraser-Beace Engineering Company, LTD where he was Chairman. His wife Muriel died some years ago. He had no children.

Marianne Miner (Mrs. **Grant Miner**), of Los Altos, Cal. wrote in late July that the House Judiciary Committee had just granted her permission to turn off the TV and take a recess so that she could respond to our letter. Said Marianne "I must say I'm enormously impressed with the quality of the Judiciary Committee. I think we'll come out of this nightmare stronger than for years". We had so enjoyed meeting the Miners in California a year ago we had hoped they might travel eastward. But it is not to be this year. The Miners keep busy with gardening, genealogical research and writing. Recently Marianne found this little gem by Jan Struther, in her mother's handwriting:

"I never see where'er I roam
A tree as lovely as a pome.
A tree is just a thing that growed
But only man can make an ode."

Brief jottings: On an Alumni Fund envelope, **John M. Sherman** reports he is still active as Curator of the Museum and Assistant to the Librarian at Masonic Temple, 186 Tremont St., Boston. . . . Emma Lloyd writes that **Phil Nelles** of Stoneham, Mass. is ill and in a nursing home, needing more care than Kay is able to give him. We hope he will soon be on the mend. . . . A card from Helen St. Laurent in late September tells of staying later than usual at Vinalhaven and having numerous guests. Theona and **Al Genaske** visited her for two foggy days with nary a beam of sunlight. After closing her cottage, Helen planned to go up to Nova Scotia for a few days. The **Dugald Jacksons** plan to spend the first six weeks in 1975 at their usual haunt, the Hy-Lander Motel in Mt. Dora, Fla. Hope we will see you in Florida.

Your Secretary and his wife celebrated their Golden Wedding Anniversary with an Open House early in October. We were honored by the presence of many friends and relatives including Maxine and **Cac Clarke**, Ruth and **Irving Jakobson** and Dorothy and **Joe Wenick**. Four red jackets were in evidence and it was a very happy affair. It has been a wonderful 50 years. . . . We learned that Cac is extremely busy with his writing and reporting for the *Coast Star* including his weekly column "Bicentennial Briefs". Maxine continues to exhibit her paintings and two of them are currently on display in the Monmouth County library. . . . Jake told us about driving to Newport and watching the first two of the America Cup Races in September. . . . The Wenicks arrived with great fanfare at the Haywards' Open House in a state trooper's car. Because of his eyesight, Joe no longer drives to any extent and had hired a car and driver to bring him over from Caldwell. The car broke down, a state trooper came by, and when he learned of the predicament, said to Joe, "Hop in, I'll drive you there". Our good friend, Russell Westerkoff '27, drove Joe and Dorothy back to Caldwell.

Your Secretaries wish you all the joys of the holidays.—**Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450, **Josiah D. Crosby**, Assistant Secretary for Florida, 3310 Sheffield Cir., Sarasota, Fla., 33580, **Samuel E. Lunden**, Assistant Secretary for California, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

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Your Secretary is leaving Buffalo during this beautiful fall season to attend electrical meetings on the west coast—thereby missing some of our best golfing weather. Perhaps we can make it up by playing with some classmates in Florida during February. . . . A card from Jet and **Ray Miskelly** showing the Jungfrau in Switzerland was written during their grand tour of Europe this summer. They report beautiful scenery and adequate accommodations. . . . Marion and **Norman Joy Greene** reported a summer visit with **Randall Spalding** at the Spalding Inn Club in the White Mountains of New Hampshire. They were most pleased with the cuisine and accommodations. . . . We were happy to receive a class letter from **Don Carpenter** saying he has returned to his winter home at Hilldendale Road, Mendenhall, Penn. We can be sure that Don is representing our class at its best back at the Institute. . . . We haven't heard the direct reports, but the 75th birthday party for **Horace McCurdy** in Seattle must have been a great one. We are indebted to Mac for sending copy 143 of his new book *Duty, Honor, Country*, a biography of George H. McManus, Brigadier General, U.S. Army. General McManus, Catherine's father, contributed importantly to the well-being of our country during his pioneering years. . . . The freshmen students at M.I.T. in 1974 included Joan E. Hooper of Beckley, West Virginia whose grandmother was **Bertha Wiener**. . . . Jeannette M. Wing of Pomona, N.Y. is also listed whose grandfather is **C. T. Chien**, our Classmate in Mechanical Engineering. The Class of 1922 Career Development Award provides support for faculty members of exceptional professional promise and unusual devotion to teaching. Dr. Joseph Ferreira, Jr., Assistant Professor of Operations Research and Urban Studies has been selected to receive the award in the Department of Urban Studies and Planning. The first award from the Fund was made in 1972 to Dr. Margaret L. A. MacVicar who will continue as Class of 1922 Associate Professor of Physics during the current academic year. Dr. Ferreira received all his degrees from M.I.T. having been at the Institute since 1967 as a graduate student teaching assistant, and instructor and assistant professor. Our class awards including the 1922 Professorship have been outstandingly helpful to M.I.T.

H. Clifford Gayley died of a heart attack Saturday, October 19, 1974 in Buck Hill Falls, Penn. Mr. Gayley was treasurer at Schenley Industries, Inc., and a Vice President for Lumber Fabricators Inc., before joining I.B.M. in 1957. During World War II he served as a Lieutenant Colonel in the Army Quartermaster Corps and was awarded the Legion of Merit. He was a member of the University Club, the Rockaway Hunting Club, and the St. Nicholas Society. At his death, he was Assistant Treasurer at St. Bernard's School in New York City, where he lived. Surviving are his widow, the former Sarah Gordon; a son, Oliver G. Gayley; a daughter, Mary G. Mari; a sister, Madeline; and four grandchildren. The sympathy of our Class is extended to them.

Our Class extends sympathy to the families of **Hector A. Lopez** of Pittsburgh, Pa. who passed away in July and **George B. Allen** of Olympia, Wash. August, 1974.

Changes of addresses include **Wallace H. Dibble**, Bristol, R.I.; **William P. Dickerman**, Taunton, Mass.; **Benjamin A. Dickson**, Devon, Penn.; **Frank M. Didisheim**, Robbinston, Maine; Mrs. Bertha S. W. Dodge, Burlington, Vt.; **Wallace B. K. Dove**, Providence, R.I.; **Howard J. Duge**, Old Greenwich, Conn.; **Adrian E. Eckberg, Sr.**, South Weymouth, Mass.; **Theodore Ellicott**, Manchester, Mass.; **Lloyd A. Elmer**, Summit, N.J.; Dr. **Nathan I. Epstein**, Chappaqua, N.Y.; **Jose C. Espinosa**, San Juan, Rizal, Philippines; **Henry J. Fagan**, Horseheads, N.Y. . . . A pleasant winter to you all and here's hoping you spend it in the kind of environment and temperature you most enjoy.—**Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

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A short time ago we had an interesting letter from **Luis Ruiz de Luzuriaga**. Luis attended the Alumni Day affairs on June 3 last and greatly enjoyed the various programs. Luis graduated with us, his son in 1952, and most recently, his grand-daughter, Catherine Felina registered for the class of 1978. While Luis was at the Institute he thought it advisable to check on her admission status with the Admissions Office. To his great distress, that office could find no listing of her name under "L", nor under "de L". Quickly remembering the confusion often experienced with listings of the names of both Luis and his son Eusebio, class of 1952, Luis persisted in his queries and to his joy found his granddaughter listed under "R" since the family name is indeed *Ruiz de Luzuriaga*. Since three generations at M.I.T. is in itself something of a record, we think that Luis' further explanation of the origin of his family name is something of a record too! It turns out that the family name originated in 710 A.D. when King Alonso of Spain was rescued from his enemies by, you guessed it, another Ruiz de Luzuriaga. Can any of us of early American, Mayflower or Revolutionary ancestry top this one?

Another interesting letter came from our good friend **Alan R. Allen**. Al is still up to his ingenious methods of curing human ills—this time arthritis. He has found pain to be much relieved by developing new methods of exercising various parts of his anatomy to encourage deep breathing. His exercise equipment includes a most complicated system of springs that, when lying in bed, he stretches, compresses and distorts these members to produce the necessary muscle and joint action. When followed by moderate temperature bathing he claims symptoms are greatly relieved. For those of you needing advice, I suggest you write him for details at 525 Lexington Ave., New York, 17, N.Y. . . . **Emil S. Birkenwald** writes—"Engaged as a consultant for two railroads in connection with design and construction of bridges." . . . We learn that recently appointed to the Council for the Arts at M.I.T. is **John E. Burchard**, historian, architect and

Dean of the M.I.T. School of Humanities and Social Science Emeritus.

Another letter comes from **Richard H. Frazier** enclosing a copy of a most complimentary letter to Davenport on the successful completion of the Great History of the Great Class of 1923. Said in a recent letter to Dave—"As one of the many members of the 'Great Class' to benefit, I wish to express my thanks and appreciation to you both for the tremendous expenditure of time and energy that must have gone into the sorting, compilation and final proofing of the material. I shall cherish the volume for myself and be proud to pass it along to my children". . . . **Cecil H. Green** has received another award. This is the Human Needs Award of the American Association of Petroleum Geologists which was presented at its international meeting held in San Antonio, Texas, in April of 1974. "As recipient of the award, Cecil was the third person to be honored for his outstanding contributions which have advanced living standards in many ways in many parts of the world through the application of geology to the benefits of man." . . . We have just received belated news of the celebration of a 50th Wedding Anniversary. This concerns **Roscoe H. (Doc) Smith** of Shaker Heights, Ohio. Shortly after our graduation Doc married Eleanor Sutton of Lowell, Mass. This of course takes us back to good old 1923. The 50th Anniversary was celebrated with their daughter, Nancy Harnsberger, her husband and three grandchildren. Doc reports—"like 23's 50th Reunion which was a grand event, our 50th was also wonderful and we are happily anticipating the 100th anniversary of both events." Good luck to you Doc—we hope you have many more anniversaries to remember!

We have also learned belatedly and in a roundabout way of the death on April 18, 1974 of **Raymond T. Willis** of Saunderstown, R.I. After graduation Ray worked as a telephone engineer until 1927 when he developed an interest in the arts, taking classes at the Rhode Island School of Design in Providence. He became successively, in addition to becoming an artist in oils, a boat builder, cabinet maker and commercial fisherman. He was a member of the Wickford Art Association and had considerable success in marketing his pictures, chiefly of marine and ship subjects. —**Thomas E. Rounds**, Secretary-Treasurer, 990 A Heritage Village, Southbury, Conn. 06488

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All of us who have been in London have heard Big Ben bong the hour and the sonorous tones slowly diminish to zero decibels. As kids, we plopped stones in still water to watch the waves dissipate in enlarging circles. These phenomena are analogous to our Fiftieth Reunion. The blast at Plymouth, Mass. in June was followed by diminishing rumbles in **Paul Cardinal**'s Final Report, our new President **Frank Shaw**'s letter and photo of September, Treasurer **Ray Lehrer**'s solvent report, and finally, gracious letters of real appreciation for the Reunion Committee's many efforts.

Jac Lehman writes, "Bravo! a magnificent affair all the way through; superior clambake, excellent cocktail party, perfect transportation handling and details beautifully carried out." . . . **Rock Hereford** says, "probably longest distance winner—Reunion so well thought out and organized. Only revision would have been to allow banquet members, so wishing, to extend greetings of classmates unable to attend." . . . **Mal Finley**: "50th Reunion a grand success. Interesting trip home via Canadian National & Jasper National Parks. . . . **George Tapley**'s letter—"It was a great Reunion which I enjoyed immensely. Everybody seemed to have a good time! In the group picture, is there a key index being made up?" Yes, George, you now have it in your mail.

The Alumni Officers Conference at M.I.T. on September 13 and 14, 1974 was attended by **Frank Shaw**, **Herb Stewart**, **Jack Cannon**, **Phil Bates**, **Dick Lassiter**, **Gordon Billard**, **Ed Moll** and **Russ Ambach**. The Alumni Association did some fast footwork when members of the S.E.I.U. and C.P.C.A. Unions went on strike, disrupting the planned dinner in Walker. All were bused to the Statler Hilton and back to Walker in the rain. Our **Luis Ferre**, president of the Alumni Association, presided at the awards luncheon. The afternoon theme was "Food, Population, Politics—The World Crisis." Morning discussion groups were based on an Alumni Survey Report on Alumni Attitudes and Opinions. "Pluralism" was the key word in the preliminary report, which was compiled from 738 telephone interviews, a unique method, which allowed carefully and broadly selected Alumni to "let their hair down" on any thoughts concerning M.I.T. No format was followed, just conversations, which were most illuminating. Summaries may be obtained by request from Mr. Constantine B. Simondes, Institute Vice President. All present received a report from John Mattill, Editor of the *Review*, providing a summary of his activities last year and forecast for the next which will include articles on food supplies, world climate trends, air traffic control, medical complexes and major world problems. The *Review* shared the 1974 Ernie Stewart Award with the "Portable Stanford" (Stanford Alumni Association), the highest honor conferred by the American Alumni Council, given for "outstanding examples of service rendered to institutions or to the cause of education by organized Alumni effort."

The sympathy of the Class is extended to the wives and families of our members who have completed their mission on earth. **Albert C. Read, Jr.** died of lung cancer August 27, 1974 in Little Rock, Ark. Bert was a friend of your scribe, running together in the 220-yard hurdles. He prepared at Phillips Exeter and received his S.B. in civil engineering. He was a member of several clubs at M.I.T. and a Phi Gamma Delt. He spent his entire career in Little Rock, but we have little knowledge of his activities.

Samuel J. Kogan passed away August 28, 1974 in Elizabeth, N.J. Alumni records indicate he was "without course" but seems to have earned an S.M. degree. It appears that he was connected with the Federal Leather Co., Belleville, N.J. in 1949. . . . **Daniel H. Mead** died September 14, 1973, in Woodbury, Conn., where, apparently, he had retired. He was a Course XV member and at one time was Labor Relations Adviser for Revere Copper & Brass in New York City, living in Blauvelt, N.Y.

Walter R. Weeks passed on August 22, 1974 at his home in Delray Beach, Fla. Walt had an S.B. in electrical engineering and in 1949 was Division Engineer for General Electric in Bridgeport, Conn. He later retired to Glenview, Ill. and finally Florida. At the Institute, he was a member of the Radio, Electrical Engineering and Choral Societies for four years. He is survived by his wife Marjorie Lowell Weeks.

Paul Tishman in New York City is the proud grandfather of James Harrison, a student at M.I.T. Paul has been an ardent supporter of the Class and has worked closely with President Wiesner on the Council of Arts at M.I.T. He is particularly interested in African art, the products of workers continuously for thousands of years. . . . **Hoyt Clarke Hottel** has been elected to the National Academy of Engineering, a private organization established in 1964 to share the responsibility given the National Academy of Science under Congressional charter in 1863. Upon request, it advises the federal government on matters of science and engineering, sponsors engineering programs aimed at national needs, encourages research and recognizes distinguished engineers. Election is the highest professional distinction that can be conferred on an American engineer. Prof. Hottel has contributed in the fields of radiative heat transfer, combustion and fuels technology.

Martin J. Buerger, internationally known crystallographer, author of eight technical books on the subject, has been a visiting professor at Virginia Tech's Department of Geological Sciences. He received his master's in 1927 and doctorate in 1929 at M.I.T. and began his career there in 1929. He retired in 1963 and joined the faculty of the University of Connecticut, retiring in 1970. He is a member of the National Academy of Science and holds membership in many professional and honorary societies here and abroad. He is now serving as an editor of an international crystallography journal. . . . And, so, with 1974 heading for oblivion, as did our Great Golden Reunion, grandchildren repeat:" 'Twas the night before Christmas, when all through the house not a creature was stirring—not even a spouse. The stockings were hung in the bathroom quite near, in hopes that St. Nicholas would bellow a cheer—"Happy Christmas to all and to all a Good Year!"—**Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Mass. 02146, **Herbert R. Stewart**, Co-Secretary, 8 Pilgrim Rd., Waban, Mass. 02168

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There have been some changes in the *Review* staff and a new person has been assigned to the handling of Class Notes. As a result I am now receiving my notice of the approach of the evil deadline with a cheerful "Hi" illustrated with a sketched flower. . . . **Harold Washburn** notifies me that he has received an appointment as Professor Emeritus at the California State University at Long Beach. . . . I received an air mail letter from **Geoff Roberts** in England asking some questions about the Reunion which he plans to attend. After consultation with **Jim Howard**, I discovered that the mailing list used for notices covers only the U.S.A., Canada and Mexico. This sounds as if "foreigners" are left out in the cold. If any of you correspond with classmates abroad,

please keep them informed about what is going on. . . . I received a telephone call from **Roger Ward** who has been visiting in Medfield. The telephone company made the conversation a little difficult as they cut us off a number of times and I was unable to call back as I did not know the number. Roger states that travel by freighter is becoming more difficult as many lines are discontinuing this service. He plans to come to the Reunion. . . . My wife and I had planned a trip to England this fall but I seem to be fated not to make such a trip as this is the second year I have postponed it. This time I spent two weeks in the hospital. After a short period of recuperation I am now up and around getting to be my "old" self and living life more or less as usual. I wish at this time to send all of you the best of the seasons greetings.

I am sorry to have to report the passing of **Charles M. Smith** of Montgomery, Alabama on August 4, 1974.—**E. Willard Gardiner** (Will), Secretary, 53 Foster Street, Cambridge, Mass. 02138

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It really looks as though this issue of notes may be an assembly job with a minimum of rambling about Pigeon Cove. After all, if Classmates are kind enough to write to the Secretary and we do not tell you about it, you may not write us the much needed letters and notes. But first let us tell you who attended Alumni Day in June, which for an off year was not bad at all since a half dozen wives and one daughter were represented. There were the **Donald Cunninghams**, the **Robert T. Dawes**, the **Robert C. Deans**, **Stark C. Draper**, **Thomas D. Green** and his daughter, the **James R. Killians**, **Morris Minsk**, **Stewart S. Perry**, **George W. Smith**, the **Abraham Whites**, the **E. B. Haskells**. . . . One loyal classmate wasn't there but he sent us a card,—**Tony Gabrenas** writes from Venezuela, "With my son John we took a tour through South America: Colombia, Ecuador, Peru, Argentina, Brazil, and Venezuela. I wanted to see how people live on the other side of the Railroad Track (rather Equator). Very poor and miserable. Waiting for the 50th to see you. It will be my 80th birthday. So long, George. My regards to classmates that still remember me."

And "**Bean**" **Lambert** recently brought us up to date on several Classmates in a letter written to us from his new home in Stevenson, Md. To quote "Bean"—"On my desk are letters from two great 1926 friends—**Ned Lame**, who is half retired as a doctor in radiology in Philadelphia, and **Fred Walch**. Fred was head of Grace's chemical plants in Europe, lives outside of Paris, and has just built a house on Lanzarote in the Canaries. . . . **Hank Hoar**, about one half '25 and one half '26, recently had a serious illness, but now is back in Williamsburg with wonderful results from treatment. My other three close friends from M.I.T. that I kept in touch with now must be contacted through a psychic medium, if you can find one with spare time, as they are completely booked up trying to reach my many departed Baltimore friends." I liked "Bean's" approach in his last sentence and hereby appoint him Assistant Class Secretary to keep close contact with these former classmates.

While some of our Class roam the globe, **Bruce Powers** reports on his summer in Arizona, "Just going through some slides and found this one that Doris took at our last reunion. This summer has been a scorcher here—broke all records. I've been home taking care of the place, the pool, and the Airedales while Doris has been in England (since May) doing research for a new book. The weather has been just the opposite there, she writes,—in the 50's and low 60's. Says she has been wearing two sweaters in the library at Oxford. She should be home this month just as our weather is becoming delightful. The fates willing and the economy not too appalling, we'll be seeing you at the 50th."

It's been a while since we have heard from **Ralph Head** but even Ralph has come through with some news this month: "**Ray Mancha**, **Elton Staples** and I get together frequently at University Club of Winter Park, Florida—(during winter months)." . . . Our distinguished classmate Jim is getting back in the news again these days as evidenced by the following news item. "Washington—A blue ribbon committee of the National Academy of Sciences recommended today that a Council for Science and Technology be established as a staff agency in the Executive Office of the President. The recommendation is contained in an Academy report, 'Science and Technology in Presidential Policymaking, a Proposal', made public at a hearing this morning before the House Committee on Science and Astronautics. After consideration of various alternative arrangements, the committee reached the conclusion that science and technology can best serve the federal government—and the nation—if adequate means are included within the staff structure of the Executive Office of the President to provide a source of scientific and technological analysis and judgment to the President and the agencies in his office. . . . Chairman of the *ad hoc* committee that prepared the report was **James R. Killian, Jr.**, Honorary Chairman of the Corporation, Massachusetts Institute of Technology."

We seldom buy the *New York Times* on a weekday but a couple of Saturdays back we picked one up and as we thumbed through we saw "**Barney**" **Gruzen**'s picture. Unfortunately the article told of his death and his achievements were such that we will quote from it. "Barnett Sumner Gruzen, architect, engineer and planner, who contributed significantly to the architecture of Manhattan's Civic Center, died yesterday in Lenox Hill Hospital.

"Mr. Gruzen was founder and senior partner of the firm of Gruzen & Partners, which became virtually the house architect for the City Hall area. The firm's buildings include the new $58-million Police Headquarters, the United States Courthouse Annex at Foley Square and the Downtown Manhattan High School; the Southbridge Towers, Chatham Tower and Chatham Green Apartments; the Bache & Co. corporate headquarters, and the Beekman Downtown Hospital staff residence.

"For his contribution to the New York City man-made environment Mr. Gruzen received the city's Diamond Jubilee Medallion last year from Mayor John V. Lindsay." For the Class our sincere sympathy to Mrs. Gruzen and her two sons. . . . We *are* writing from Pigeon Cove and it has been a great fall here. Many are still sailing but our boat rests on its trailer at the club waiting to be brought home and tucked into its special third stall in the garage and a list of experimental projects for the boat that will go on through the winter. But for now our collie "Heather" is patiently waiting for me to take her on a walk up Pigeon Hill—elevation 200 ft. and view of the sea panorama. Today we should be able to see Portsmouth. So—if you will excuse, we will say "Cheerio" and be on our way.—**George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

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I am writing this the day after flying back from Amsterdam, and after a full morning of going through several weeks' accumulation of mail. It was disappointing to find so little in the pile that is usable in the notes. With so many of the class retired or semi-retired, there must be many with time to write, and interesting activities to write about. . . . We were in Britain for about ten days before the October election and a week or so afterwards. We talked with many Britishers about the political and economic outlook, and found a lot of discouragement and apprehension. I can't say we met a very representative cross-section of the population—one man was a rabid Scottish Nationalist whom we met in Edinburgh, and the rest uniformly identified themselves as Conservatives (several said "Tory"). Perhaps those who voted the labour majority in are more optimistic.

Charlie Hurkamp is keeping himself busy with inventions and product development in the field of shipping containers. He retired after 43 years as an aeronautical engineer and is living at Sea Pines Plantation, Hilton Head Island, N.C. . . . **Harry Moser** has also been living in North Carolina since his retirement two years ago. He spends his time on a number of hobbies—mineralogy, electronics, museum work, and travel—and reports that he has also been looking up fellow alumni in the area. . . . **Win Witham** came out of retirement a couple of years ago—after eight years in retired status—to join his son in highway construction, but he says he is now giving thought to retiring again. . . . There was quite a spectacular retirement party for **Al Jacobson** this past summer when he retired as chairman of the Board of Assessors of Malden, Mass. It was a benefit party, with proceeds going to the University of Abak Center, which serves Adiasim, Nigeria, designate as a "sister city" to Malden. The Center itself is in Ann Arbor, Mich. It devotes itself to fund raising and support for community schools in Adiasim, which is one of the most densely populated areas in Africa and has a 94% illiteracy level. When Al took his degree, he joined the family building firm in Malden, specializing in pre-fab homes. He retired from the firm in 1956. Meanwhile, he had been elected to the Board of Assessors in 1939 and became chairman in 1961. He had also served for a dozen or so years on the Malden Board of Appeals, and has been active as a director of local savings banks, in Rotary, and in various other county and city activities. —**Joseph H. Melhado**, Secretary, 24 Rodney Road, Scarsdale, N.Y. 10583

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Our greetings to all of you with best wishes

for a pleasant holiday season and for good health in the year ahead! We have had a most welcome letter from **Lazare Gelin** following his return from an extensive trip abroad. Lazare retired two years ago from regular business in foreign trade but he still does some consulting work in that field. He reports that the Gelins are well and enjoying languages, literature and music at their home in Westport, Conn. The oldest of their seven grandchildren entered Radcliffe College this fall while the others all aspire to follow.... **Onnic Susmeyan** continues to do consulting work in the field of electronics, mostly relating to manufacturing. This, along with photography and home maintenance projects, occupies his time. Wife Kay, a graduate of the New England Conservatory of Music, plays the piano, composes classical music, paints and writes poetry. Occasionally they make a trip to Florida.... Iris and **Phil Taylor** are happy in their retirement. Summers are spent at Dennis on Cape Cod and they are at home in Walpole, Mass. during the rest of the year. Hiking is something they both enjoy and it keeps them fit. During the past 15 years they have walked most of the beaches on the Cape. Bird watching is another activity for wherever they may be. In season they attend symphony concerts in Boston with friends. In the summer of 1973 they went to Europe for six weeks and traveled in Switzerland, France and along the Mediterranean Coast. While in the Alps they walked down from the upper base of the Matterhorn. Phil has always enjoyed French as a language and this interest, shared by Iris, served them well during the trip. Along with all of this Phil still does some consulting work and is active in his church. The Taylors have every intention of attending the 50th Class Reunion.... News from **Art Josephs** comes to us via a letter from his wife Adrianne. They have been busy remodelling their home inside and out, doing civic jobs, and assisting in opera related activities. As if this were not enough, they are planning to take some courses at college this winter so as to keep up with the young people of the family.... From Madrid, Spain **Hector Hagedorn** says he is willing and ready to help **Jim Donovan** with the 50th Anniversary Class Gift effort.' ... We have learned that **John Leslie** was made a Fellow of the Society of American Military Engineers in May, 1974.... We note that **Gus Solomons** is on the New England Advisory Committee for the United Negro College Fund, Inc., a most worthy organization.... Another pleasant letter, this time from Mary and **Max Parshall**, tells of their activities this past summer. The highlight was a trip east in June with eight days spent on the coast of Maine after attending a notable wedding in Winchester. The rest of the summer was taken up at home in Montana with gardening, music, entertaining, local trips by car and a bit of fishing. Except for a few joint aches Max reports his physical condition as essentially good.... **Mary Nichols** is now well established in her attractive new condominium home in Farmington, Conn. Those of us who have visited were much impressed by the beauty of natural grounds, clever planning of dwellings and the many recreational facilities.... Catherine and **Don Sturznickle** wrote us an enthusiastic letter of congratulation. At the time of writing they were about to leave home in Houston, Texas to attend the 50 year reunion of Don's high school class in Erie, Penn. Their closing wish applies to all of us: "Many happy reunions to come!"

With deep regret we must report the deaths of two classmates. Rear Adm. **David S. Crawford** died on April 29, 1973. The information was received only recently from his wife, Constance, to whom we send our heartfelt sympathy.... **Joseph V. McQuillen**, who graduated in Course VI, died suddenly on June 22, 1974. To his family we extend the sincere sympathy of the Class.—**Walter J. Smith**, Secretary, 37 Dix Street, Winchester, Mass. 01890

The Widgeon, the Goose, and the Mallard: With these Has Come True Freedom

Imagine the infinite number of sheltered bodies of water that rim our coastline, myriad inland lakes and rivers . . . to Franklin T. Kurt, '27, these also serve as smooth, large, ready-made landing areas complete with more adjacent facilities than airports.

The first M.I.T. graduate to receive an S.B. in aeronautical engineering—at a time when there were as yet no airlines in the U.S.—Mr. Kurt went immediately into commercial flying by taking passengers on sight-seeing flights in both landplanes and seaplanes. He gave Amelia Earhart the refresher course she needed to claim her first pilot's license, designed the Kitty Hawk open-cockpit byplane, redesigned the French Schrect flying boat as an amphibian with an American engine, and in 1929 became Chief Engineer and Test Pilot for the Viking Flying Boat Co. at the New Haven airport.

Later, working for the Grumman Company for years testing and demonstrating the Grumman Amphibian to prospective customers, Mr. Kurt often piloted the airplane for owners on their first trips, his adventures extending into the tropics and deep into the Canadian bush.

The Widgeon, the Goose, the Mallard—these were versatile small planes that had the speed of the airliners of their time but were at home at large airports as well as anywhere a small power boat could go, waddling out of the water onto the beach . . . with the ability to be parked on an owner's shorefront estate. Think of the possibilities of these vehicles for taking the children to the dentist, chauffeuring from a Wall Street ramp in the evening, going salmon fishing in Newfoundland. Expensive—but perhaps the most desirable private airplanes ever built, thinks Mr. Kurt.

Franklin T. Kurt

Franklin T. Kurt's book of reminiscences, *Water Flying* (New York: Macmillan, 1974, $8.95) is written with a combination of exuberance, awe, and delight: "Water flying brings a new sense of freedom, a release from restriction. It is like a return to the old days when precise navigation was unnecessary and skies were uncongested. . . . You fly relaxed and discover anew the enveloping beauty of nature."

Mr. Kurt is the empathetic teacher—"You get excited. You're not used to seeing boats—on the runway! . . . There are five basic precepts:

1. Observe—observe—observe—observe
2. Think—analyze—verify
3. Plan ahead—replan
4. Execute
5. Abandon—and try again."

Complex forces are discussed with simplicity. One of the fundamentals of flight is described by saying that for a wing or propeller it was more efficient to push gently on a lot of air than to push hard on a little air.

Mr. Kurt now lives on his island off the coast of Maine, where the seaplane is an important means of transportation as well as a continual source of enjoyment for him.

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Prof. **Walter H. Gale**, known to all his classmates and friends as "Wally", has sent a good news report which speaks for itself, as follows: "Dear Karnig: I have not responded to previous birthday greetings from you, not for lack of appreciation, but because we have cluttered up your class notes too often in the past. As I wrote to you two years ago on a card from Invercargill, New Zealand, the farther one gets from home, the greater his urge to deluge his friends with epistolary inanities ("having fine time, but wish we were there"). We have already sent greetings to you from Angkor Wat, Leningrad, Uganda, and Pitcairn Island,—but never a note from New Hampshire!

"And so, lest we seem ungrateful and ungracious, may I thank you for your recent birthday card, as I sit in our little red farmhouse here in Melvin Village, looking out at the Ossipee mountains ten miles away. Except for our jaunts abroad, we live here the year 'round,—in peace and quiet for ten months, and in the turmoil of summer traffic the other two. As Marion Robie, our postmistress and owner of our local telephone company and general store, once said when asked what she did when the summer people left: "We fumigate."

"I phased out and away from the Institute

during the sixties, after twenty-plus years on the faculty and administrative staff. My only tie now, except for alumni affiliations, is membership on the Corporation Development Committee. Joan and I return to Boston weekly throughout the "symphony season," and if any classmates happen to be spending a Friday night at the Ritz-Carlton this fall or winter, please check the front desk, as we have 25 confirmed reservations between now and next April. We would love to have an impromptu, unofficial reunion, as we missed the 45th in June.

"Neither our son or daughter has married, so our only grandchildren are four-legged ones. Son Tom is a roving professor, having had teaching positions in Kobe, Japan, Leysin, Switzerland, AshfordDowns (Sussex), England, and now at the U.S. International University in Nairobi. Between jobs he has managed to find time to get his master's degree at Harvard and his doctorate at London University. Daughter Joanie is gainfully and happily employed at M.I.T. in the Design Services office (formerly Office of Publications). She commutes weekends to her new house on the top of a mountain in back of Melvin Village, with a spectacular view and 40 acres of woodland around her.

"The property is a spin-off from my brief career in the land development business up here, which I started with Jerry Blakeley '14. He is now President of Cabot, Cabot and Forbes, New England's most prestigious real estate firm, and I ended up as secretary-treasurer of the local cemetery association. The financial end of this business being slow, I spent this morning aerating and spreading lime on the lovely green sward down by the Melvin River, in back of our little white church . . . I wonder what Jerry is doing today?"

Col. **George D. Rogers**, writes: "My wife Hope and I will be attending the 55th Class Reunion of my U.S. Military Academy at West Point, May 29-31 ('74), and in July, we plan to attend a World Convocation of our Church in Mexico City, followed by a tour of Mexico. I am enjoying my retirement and our activities include church and civic affairs.

Kenneth D. Beardsley was recently retired from G.E. after 45 years of service. His career was devoted almost exclusively to the study and development of sophisticated metals and new designs for the cores of transformers. For his knowledge and innovations, he received two managerial awards, in 1954 and 1963, and eight patents relating to core design. He was also named a fellow of I.E.E.E. One of his life long hobbies has been the organ and organ music. Since retirement, he has gotten himself a part time job in an organ building and maintenance company. The Beardsley family has been active as organists for many years. Ken has been the organist of the Zion's Lutheran Church in Pittsfield for 38 years, his wife Barbara plays at the Grace Episcopal Church in Dalton, son Bruce is the organist in an Episcopal Church in Rochester, N.Y. and son Peter provides the music for services at the Pittsfield First Methodist Church. Ken's interest in the "Queen of Instruments" stems from an organ recital he heard as a young man. Though he is largely "self-taught", he is a charter member of the American Guild of Organists (Berkshire Chapter). It looks as though Ken has retired from giant transformers to the intricacies of the organ.

Everett F. Kelley writes: "though I have been retired since 1970, I keep busy doing carpentry, painting, landscape, and gardening on a part-time basis. My wife and I have traveled extensively in Europe and in the U.S.A. We like the Cape best of all. We are celebrating our 45th Wedding Anniversary—been married to the same woman that long—Amen. Thanks for the Birthday Card".

Rodolphus A. Swan, Jr. writes: "We had planned to take a trip to California last winter to spend Christmas with our daughter Ellen, but the gasoline shortage made us change our minds. In New Hampshire where winters are cold, we were much more concerned with oil for heat. There were times that oil was scarce, but as soon as the price went up, the supply became plentiful. We have three fireplaces in our three year old house, one in the living room, dining room, and kitchen. Since we had plenty of wood, we had the fireplaces going most of the day. Except for a hernia operation last November, my wife and I feel fine. We could not make the Reunion because of a family gathering at Edgartown. Best regards to all."

Maj. Gen. **Leslie E. Simon**, U.S.A. (Ret.) is enjoying his leisure time in the warm climate of Winter Park, Florida. He is doing just enough consulting work in science and management (statistical methods, quality control, management of research and development) to keep himself from being bored. . . . **Henry F. Robbins** writes: "I am leading a quiet life here in New Fairfield, Conn. Those of you who are interested in "Law of Probability", here is one: There is a Henry F. Robbins (no relationship) in this town, who purchased his house the same year as I did (1973), his father comes from Kingston, Maine, same as mine, the last four digits of his phone number are same as mine and he drives a Vega, same model, same year and color. If and when some of you retired mathematicians have solved it, I would like to know. Speaking of my car (Vega)—recently, I took a trip through New York State, and averaged about 36 miles on a gallon of gas."

Hugh Hamilton has sent me a note thanking all those who remembered him by signing a greeting card at the Reunion. Recently he had a vein operation in his bad leg to facilitate better circulation at Mass. General Hospital. His wife Helen informed me that the operation was a success and they planned to leave for Florida directly from the hospital. . . . **Kenneth G. Russell** has retired from his engineering profession and doing some part time work in real estate. He keeps himself busy doing chores on his house and gardening as well. His daughter Susan is in her first year at the Michigan State University. . . . **Alfonso Tammaro** writes: "Since retirement in 1965, I became a member of the 'Special Corps of Retired Executives' and a member of the U.S. Army's advisory committee on our Voluntary Army." Before retirement, Alfonso was associated with atomic research and development. He was listed in *Who's Who in America* (1956-1958), *Who's Who in the East* (1964-1971) and *Who's Who in Atoms.* He is also listed in *American Science, Dictionary of International Biography,* the *International Yearbook* and *American Men in Government.* His contribution to atomic science is acknowledged in two recently published books entitled *The Manhatten Project,* and *The Atomic Shield,* which covers the history of the U.S. Atomic Energy Commission from 1947 to 1952.

Howard Pankratz writes: "My wife Margaret and I spent several weeks during December, 1973 and the following January with our daughter, Nancy and her husband, Peter L. Ames in Evanston, Ill. We enjoyed seeing our two grandchildren, Elizabeth, ten years old, and Charles, four years old. We stayed at a nearby hotel and did a lot of babysitting and sightseeing with the grandchildren. Charles loves peeled apples and he liked the careful way I performed the task and earned the title of "The best apple peeler in the World". We are planning to attend our 45th Reunion depending on Margaret's eyes. She has had several cataract operations on both eyes. . . . A brief note comes from **Roger A. Sykes** as follows: "We are now living on Casey Key, near Sarasota, Florida. Hobbies include travel, water color painting and golf."

I regret reporting the deaths of several members of our class during the past year. In response to a birthday card to **George G. Mintz**, who worked for Kimberly Clark De Mexico, I was informed that he passed away two years ago. . . . Similarly, the widow of **V. Edwin Ware** writes that her husband passed away on December 31, 1973. . . . **Willard Dodge** passed away on July 29, 1974, less than a month after he retired from the U.S. Naval Department with 34 years of service. He is survived by his wife Elizabeth M., four children and eleven grandchildren. . . . Tom Marlow '55, writes that his father, **Arthur B. Marlow** died on July 27, 1974 following a blessedly brief terminal illness. During his career, he was involved in heavy construction of roads, railroads and dams. His last project before retirement was at the Mangla Dam Project in West Pakistan. . . . A note from the widow of **Paul S. Kingsley** states that Paul died on May 16, 1974 while undergoing open heart surgery at the Cardiac Clinic of the University of Washington. "The last few years", she continues, "Paul had been greatly restricted physically though his mind was still that of an inventive-engineer. He was a great problem solver, not only in his field of metallurgy, but other fields as well. I feel very strongly on the matter of abilities of 'senior citizens' to be allowed to go to waste. I wish that M.I.T. might spearhead a drive for a "Senior Achievement" program operating somewhat like the "Junior Achievement" at High School level." He was associated with the Chemical Processing Division of General Electric Co. for over 21 years. He was the author of several technical articles on Metallurgy and served in the Navy for three years. He is survived by his wife Mary, son Richard, and two brothers and a sister.

Captain **Wendell Kraft**, U.S.N. (retired) passed away on July 15, 1974. He was a professor emeritus of engineering at Trinity College. He joined the Trinity faculty in 1954 after 34 years career in the Navy, where he was an Assistant Chief for Administration of the Bureau of Ships. During World War II, he was hull superintendent and production officer at the Charleston, S.C. Navy yard, and later, he was production officer of the Boston Naval Shipyard. He was a member and former Vestryman of St. James' Episcopal Church in W. Hartford, Conn., the Honorary Physics Society, Phi Lambda Phi, the Navy League, Director of the A.A.R.P., former member of the West Hartford Y.M.C.A.

board, a member of the Greater Hartford Big Brothers, and a 1,000 hour award winner for volunteer service in Hartford Hospital. He is survived by his wife, Dorothy, a son, Capt. Frederick W. Kraft, serving with the Sixth Fleet in the Mediterranean; and two daughters.

Kenneth W. Grimley, nationally known layman in the battle against tuberculosis and other respiratory diseases, died suddenly on Wednesday, April 10, 1974. He was in Jackson, Miss, attending the annual meeting of the Mississippi Lung Association and was to have addressed the group the following day. He was executive director of both the Alabama Lung Association and the Jefferson-Shelley Lung Association. Since early 1930, Ken's name has been synonymous with the fight against emphysema, tuberculosis and other chest diseases. He became executive director of the Anti-Tuberculosis Association of Jefferson County in 1933, and took over the reins of the Alabama statewide Organization the following year. The Christmas Seal Campaign in Alabama rose from less than $13,000 to more than $500,000 under his leadership. Also under his leadership one of the first mass chest x-ray programs in the United States was established in Birmingham. In 1965, he was the first Tuberculosis Association executive to receive the Will Ross Medal for distinguished contributions to the control of TB. The citation closed with Thomas Jefferson's quotation: "I like the dreams of the future better than the history of the past", which was his favorite. He is survived by his wife, Emmie Lou and a son and a daughter.—**Karnig S. Dinjian**, Secretary, 6 Plaice Cove, Hampton, N.H. 03842

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During the last few months our most distinguished naval architect and the designer of the successful America's Cup defender Courageous has been much in the news. If the newspaper reports are correct, Courageous is the sixth successive and successful Cup defender that **Olin Stephens** has designed. It seems unlikely that this record will be duplicated in the near future. . . . Once again we have at hand a number of communications from retirees, some of which have been previously reported. **Ernie Reisner** is now "100% retired and enjoying it"! His principal hobby is sailing off the eastern coast of Maryland where he says that he occasionally bumps into **Hank Luykx** who is also a sailor. . . . **Stan Russell** retired several years ago as President and Treasurer of Johnson-Foster Co., an industrial painting concern which does contract painting of schools, hospitals, colleges, office buildings and work at various military and navy bases in New England. The Russells have two sons: Stanley, Jr., who is an accoutant in San Francisco, and Robert, who is a doctor now stationed at the Nemanzee Hospital in Shiraz, Iran. Stan says that he and his wife hope to go to Iran next year to visit their doctor son Robert and his family. . . . **Ted Ross** retired as "Manager-Engineering" from General Electric (Fort Wayne) about five years ago and has maintained quite an active retirement schedule. He has continued as Treasurer and Choir Director of the Memorial Baptist Church and is on the Advisory Committee of the Foster Grandparent Program in Fort Wayne, as well as president of the Fort Wayne Seniors' Golf Association. The Foster Grandparents Program involves work with children at various day care and handicapped children centers and making arrangements for grandparents to spend time with those children at such centers that need continuous and close association with someone who cares for them. The grandparents receive a modest salary for their work.

The Fort Wayne Seniors' Golf Association is also an interesting activity. It appears that this is a city-wide program which permits the seniors, for a modest fee, to play any of the city's public courses on Mondays and Fridays. According to Ted the program is very popular; out of a total membership of about 250, some 225 people play on a typical day. At the end of the golfing season in October, there are usually four scrambles and a four-course tournament. Ted reports having recently seen three classmates, all of whom are retired. . . . Arnold Childs, '31, retired some years ago from Sunoco and spends his summers in New Hampshire and winters in Siesta Key, Florida, or on tramp steamers travelling to various parts of the world. . . . **Myron Smith** retired from General Radio some years ago and also spends his winters in Siesta Key, except that he will make an extended trip on a freight steamer this winter. . . . **Irving Dow**'s retirement has been previously reported. . . . Last July **Walter Soroka** was the recipient of "The Berkeley Citation" of the University of California "for distinguished achievement and for notable service to the University." . . . **Haskell Small** is still working in real estate and property management. He is a member of the Board of the Opera Society of Washington, the National Choral Foundation and the National Children's Center; also treasurer of the Arts Club of Washington, president of the Baroque Arts Society and president of the Jewish Historical Society. Haskell says he hopes to be at the 45th Reunion. . . . **Rollin Rosser** is still working as an architect and engineer in Dayton, Ohio. He is a past president of the Architect's Society of Ohio and a past president of Montgomery County Planning Commission. . . . **Arthur Roberts** is Department Chairman of the Department of Manufacturing Engineering Technology at Norwalk State Technical College in Norwalk, Conn. He says that his first textbook *Programming for Numerical Control,* published in 1968 is doing well. He plans to publish a second textbook *Manufacturing Processes* in the next year or two. Both books are designed to meet a need for usable information at the junior college level—**Gordon K. Lister**, Secretary, 530 Fifth Avenue, New York, N.Y. 10036

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O. Mason Burrows writes that he retired from the Norton Company on January 31, 1974 after working 39 years and 9 months. He is now working independently as a ceramic engineer/consultant and also sailing a Tartan 27 out of Wellfleet. He has issued an invitation to come and join him. . . . **Jim Fisk**, who has retired as President of Bell Telephone Laboratories has been elected to the Board of Directors of General American Investors Company, Inc. . . . **Don Sinclair**, formerly Chairman of the Board of General Radio Company, retired on June 6 after nearly 40 years of service. Don first worked for General Radio while studying for his doctorate in the Department of Electrical Engineering at M.I.T. He joined G.R. on a full time basis in 1936, was elected President in 1963 and has held the position of Chairman of the Board since 1973. During World War II, he was in charge of the search-receiver work for radar countermeasures at the Radio Research Lab at Harvard and was a member of Division Five of the National Defense Research Committee on Guided Missiles. For his work, Don was awarded the President's Certificate of Merit in 1948. . . . Word has just been received from the International Executive Service Corps that **Robert Martin**, of Cotuit, Mass., has been given a project assignment for three months at Maquinas Sao Paulo, Brazil, to help the machinery company consolidate manufacturing operations at a new suite. . . . Congratulations to **Arthur A. Smith** on his election as Executive Vice President of Stone and Webster Engineering Corporation. . . . A note from **Gordon Brown** advises us his mailing address from October 1-June 1 will be Room 4-234, M.I.T., 77 Massachusetts Avenue, Cambridge, Mass. 02139, and that for most of the winter of 1974-75, he will be renting an apartment at 39 Chester Road, Belmont, Mass. During the summer, his mailing address will be Beaver Island, U.S. Mail Boat, Lakeport, N.H. 03246. (Telephone 603-279-6118) . . . Saw Hope and **Randy Binner** recently for a few minutes. Both seem to be in good health except for a sprained ankle suffered by Randy while visiting his old office.

A most welcome letter from **Emile Grenier** enclosed a clipping from the October 16, 1974 *Ann Arbor News* from which I quote in part—"Passage of the anti-interlock legislation was a personal victory for an Ann Arbor resident, Emile P. Grenier, a retired Ford Motor Company engineer. Grenier spent thousands of dollars of his own money in newspaper advertisements and mailings to congressmen urging the interlock removal. He also made several trips to Washington to hand deliver studies made on the interlock. He contended the system was dangerous and a needless expense." Congrats Emile, keep up the good work. In his letter, Emile wrote "I am presently engaged in getting the Congress to realize that the Air Bag is also potentially lethal. In a recent report made by Mr. Ake Anderson (presented to the American Association for Automotive Medicine in September, at Toronto) of Volvo, Sweden, covering a series of 24 live tests of simulated standing children with their chests up against the airbag, eight were killed." Emile is sending copies of this report to all senators and eight congressmen—and continuing to be active in the field of auto safety. He is also starting to work on eliminating the $2,400 limit on earnings now imposed on all of us by the Social Security Law. I am sure we all hope he will be as successful in this endeavor as he was with the auto interlock. . . . Have a Merry Christmas and all the best for 1975.—**Edwin S. Worden**, Secretary, 35 Minute Man Hill, Westport, Conn. 06880; **Ben W. Steverman**, Assistant Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216; **John R. Swanton**, Assistant Secretary, 27 George St., Newton, Mass. 02158

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Thomas W. Mackesey retired on June 30th as Professor of Regional Planning and Vice President for Planning at Cornell University in Ithaca, N.Y. He was a member of the Cornell faculty since 1938. Professor Mackesey was instrumental in the development of a long-range policy for future campus development at Cornell. After serving three years as Dean of the University Faculty, from 1961 to 1964, Mackesey was named Vice Provost and then Vice President for Planning in 1971. He was Dean of the College of Architecture, Art and Planning from 1951 to 1960. He organized the Department of City and Regional Planning at Cornell, one of the first in the country. That department grew from one professor and one graduate student to two departments with a faculty of 14 and 120 graduate students. He also participated in studies for the site selection of Brasilia, the new capital of Brazil. Cornell's President Dale R. Corson, in paying tribute to Professor Mackesey, noted his "long and distinguished service" given to Cornell.

Isaac Schwartz has reached a most important milestone and reports very proudly that he has reached the distinguished state of being a grandfather. Isaac also notes in his activities report that he is still working energetically for himself at H. Schwartz & Sons with three branch outlets. . . . **F. R. Smith** relates that he has been operating the Fraen Corporation, Wakefield, Mass., for the past 37 years, engaged in the manufacture of small and medium stampings, screw machine products and assemblies, finished or unfinished. . . . **Russell S. Robinson** advises that he is enjoying retired life in and around Tucson, Arizona. Russ, with his wife Sylvia, keeps very fit backpacking, camping and hiking in Mexico and Arizona, usually with the Southern Arizona Hiking Club, and also playing classical piano. For technical stimulation, Russ is engaged in a private venture, developing a new trailer for towing behind pedal bicycles for use in shopping, picnicking and camping cargos. In addition he continues his consulting work with Battelle Institute, as a faculty advisor in residence at Tucson. . . . **Richard M. Stewart** in a recent note informs me that the first year of his new assignment as the Commissioner, Department of Commerce, State of Connecticut, has been very different after a lifetime of work in the Anaconda Company, the last twelve years as President of Anaconda's American Brass Company. Recent advertisements in the *New York Times* and trade journals attest to Dick's ability to attract new industry to Connecticut. . . . Among the new freshman students I am pleased to announce Sarah S. Huested, daughter of **Richard S. Huested**. . . . At the recent Alumni Officers Conference your secretary had a delightful, but too brief, reunion with **Don** and Bettie **Whiston**, **John** and Dottie **Finnerty**, **Bunny Nealand** and **Harold Tonsing**. **Wendell Bearce**, **Arthur Lowery**, **Raymond Schaefer** and Professor **Albert Stewart** were among the registrants, but unfortunately a strike of the custodial employees prevented the usual opportunities for visiting.

It is my sad duty to report the passing of two classmates, **William H. Barker**, April 28, 1974, and **John J. Such**, June 29, 1974. Bill Barker, you will all recall, I am sure, was first marshal of our class, a member of Lambda Chi Alpha and Pi Delta Epsilon fraternities, the Osiris Honor society and the Educational Council. Bill had been very active in civic affairs in Rhode Island, The Cranston Kiwanis Club, the Warwick Boys' Club and the Town Criers of Providence. . . . John was very active in the town affairs of Wrentham, Mass., having served several years as a member of the Wrentham Finance Committee and the Wrentham Industrial Development Commission. Our sincere sympathy to their respective families.—**John W. Flatley**, Secretary, 6652-32nd Street, N.W., Washington, D.C. 20015

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Again, the time has come to talk, and we do have many things. Please recall the fine letter sent you by our genial President, **Dayton H. Clewell**. That letter was a veiled scolding, and, quite for sure, it bore fruit, though not over-whelmed with messages from new sources, we do, indeed have a few, and I am encouraged. I must, perforce, use my material, this time, in chronological order as there are quite a few smaller items. . . . **Bob Timbie**, always alert, sent me nothing on himself, but dwelt on **Al Payne**, still of St. Louis. So, with Bob's lead, I wrote Al to see what gives. Al, it seems, quit Monsanto August 31, after 35 years. After selling the Missouri home, Al and Betty will move to Sun City, Fla., where the new home is almost completed. Both Paynes are golfers, and plan to base their activities on that, plus, in warmer months, they expect to travel to visit a widely scattered family, in Virginia, Chicago, and Phoenix. To Al, Florida is laden with classmates, and, if requested I can furnish names and addresses, but, you must report back to me, or no soap. Thanks for the fine note, Al and Betty. We love it.

Prentiss (Lobby) **Lobdell**, and his lovely Marge, spent a couple of great hours on our porch at the farm, in mid-August. They were on a rather extended trip, having left Longboat Key in early June, and travelled all over the northeast, the Maritime Provinces, and the Gaspé. They stopped in on **Mal Mayer** in Washington, Maine en route. We talked of many things, like the Mexico City Club Fiesta, and, they are from now on addicts. After Exeter, they were headed for stops in southern New England. Golly, y'all can do me no greater favor than to drop in and enjoy a drink with us at Fort Rock. For us it is the best of the year. . . . Vice President **Beau Whitton**, and his Daphne, phoned from nearby, in late August, but Leona had to tell them that I was at the New York State Fair at Syracuse. Well I was, and I am the loser. Beau had no time to wait for me, but, later, I got a card from Fredericton, New Brunswick, where his son is teaching at the St. Thomas University. Further, the Whittons' two granddaughters, are age two plus, and one-half years. While there, they visited the Provincial Fair, saw some Angus, and found out (?) that the cows have calves every 24 months. He must have got that from a granddaughter, and, a letter to him rearranged the facts (they calve every year, or else.) . . . We have still another from Beau—this time via the Alumni Fund capsule. Though this arrived last, it was written before the long trip. Beau is preparing for retirement, and is on his way, taking two 30 day vacations every year. It seems that the proposed trip was to follow the 40th Reunion, but they were not able to do either in '73. Many thanks, Beau and Daphne. How nice it is to hear from you, and how nice for your classmates.

Now for three items from the irrepressible **Cal Mohr**. First a copy of a letter to **George Henning**, wherein he relates a short conversation concerning George's search for scrap mercury, and what to do about it. While in St. Louis, earlier, Cal talked with **Ellis Littmann**, who right then was about to take off for Cambridge, to discuss Class Estate stuff. Cal, it seems, is to retire from Sperry Oct. 31, and after finding an apartment, will live in E. Liverpool, Ohio. (East Liverwurst and Stupidville are familiar towns, in S.E. Ohio, suburbs of Pittsburg.) Cal plans to go into Consulting, as this appears to be a safe haven for these retirement fellas. . . . He also hears that **Slick Henderson** took part in a telethon, St. Louis, earlier, as a part of the Alumni Fund effort. On Sept. 18th Cal feels sorry that we have had so much rain—haw! Two and a half inches June-July-August. Now (Oct.) a total of 7.90 inches. . . . It seems that **Skee Sysko** is enjoying his retirement in Florida, and is playing lotsa golf. Many thanks, Cal, hope that you and Jean make it at East Liver.

From **John B. McAleer** comes a notice of retirement, and at present engaging in Coastal Engineering Consulting. John was with the Corps of Engineers for many, many years. Thanks John, and I do love those Alumni Fund capsules. . . . Another capsule is from Mrs. **Muriel B. Wilbur**, of Attleboro, Mass. Muriel appears to be a loyal alumna, as witness the Fund capsule. She is President and coordinator of the Health Care Administration in Boston. You will recall that Muriel was one of our coeds who took her masters in Course VII, then biology and public health. Muriel, we especially enjoy hearing from one of our few coeds. There were few, though now there are many. . . . Now comes **Walt Duncan**, who appears to be an inveterate traveller, mostly on business. But, recently, they travelled to Los Angeles, to see number one son, wife and two granddaughters. This, before said family left for Thailand to evaluate an irrigation project. This son is soon to receive his Ph.D. in anthropology. Next trip was to Elmira, N.Y. to see a daughter, who has two sons, and, a daughter. Her husband is a Yale engineer, in electronics, with Westinghouse. Next visit was to Hanover, N.H. where number two son is a professor of German. He has a son and daughter. Walt is to retire in 1976, and the Duncans just celebrated their 40th wedding anniversary. Walt says that many classmates have known Janet all along, as she went to Wellesley, so know why this union has worked out; a college romance, yet. Walt says that they used route I-91 to Hanover, so did not get too close to Exeter. Walt is an Exeter Academy grad, 1929. He is looking forward to our 50th, eight plus years from now. I had Walt interested in the blind, at home. Not so, sezzee. His interest is in boy scout work. Now, who in the Philly area is a worker for the blind? Many thanks, Walt, for writing such a nice long note.

From **Warren S. Daniels** comes a fine letter, in which he informs us that he attended an August annual meeting of the Washington, D.C., M.I.T. Club, when most of the time was spent 80 feet underground in the new Washington Metro system, (under construction). The whole group walked un-

derground from 4th St., to 11th St. and saw three new stations almost ready. Warren tells us that his father spent most of his life as an engineer with the Boston subway system. Warren and Dorothy took an extended vacation, three and a half weeks in Greece, the Greek Islands, Turkey, and, fortunately early, to Cyprus. In Turkey, they visited way into the interior, to Ankara and Cappadocia, and had a swim in the Dardanelles. It seems that in late August, Warren suffered a bit with acute bronchitis, and, while en route to recovery, took a bad fall, and gashed the back of his head. Now, Warren is not famous as a teetotaler, but, gee, he did say the back of his head. Warren, you old fellas musta missed playing football in your youth, as those fellas learned to fall relaxed, and not on the back of the noggin. Now, second childhood has set in; Warren and Dorothy are to return to school, for special studies, at the Northern Virginia Community College. Sayeth not how special these studies are; M.I.T. does put out a few not completely educated. We are glad to hear that youngest son, Dave, has been out of the Marines long enough to take a degree at V.P.I. Now, a post card clarifies where the heck is Cappadocia (it was my question). It is southeast of Ankara, in the area famous for soft rock formations, in which homes and churches were carved by early Christians, A.D. 1200 approximately. The card also explains special studies; they are travel and tourism. Golly, does one hafta study this? Well, it comes naturally to most of us. Now for the punch line: Mexico City Fiesta is high on the list for the future, soon. Thanks, Warren, and Dorothy: it is sure nice to hear from ya!

Now comes **George Ropes**, of the Scarboro Ropes. George says that he is still acting as math coordinator in White Plains, does some tutoring, and teaches some college math. He loves it, but mostly because of the long vacations. Reminds me of one of the American League umpires, who said the job is so so, but you can't beat the hours. The Ropes have just returned from a long summer in Marshfield, Mass, spent with the family, including one grandchild. One daughter is married and living in London for a year or so, and the Ropes visited her, earlier. A son is teaching Spanish, at a private school. And, as mentioned here, before, another daughter is vegetable farming, at least so far, though they intend to go more into animals, later. The Ropes youngest daughter is still a student, but now at the University of Wisconsin. When George wrote the letter, he intended to be in Marshfield, and to attend the Alumni Officers Conference. I do believe that George didn't make it, or at least I didn't see him; see later in this missive. Thanks a million, George. P.S.—George insists that his name is Ropes, not Lopes, as suggested in the Review puzzle column (that one escaped me). Also, words like "Abditory" intrigue him.

Now, for a change, not necessarily refreshing, but nearly so: **Emmy Norris** dropped in a while ago, as is his wont. We discussed the state of the nation but will make no recommendations, and of course, them democrats. In fact we covered many things but not including pornography, and I submit that we are too old anyway, and not particularly informed. Emmy and Christine spent the summer in Hiram, Maine, watching trees grow, a pursuit though not fatiguing, really takes time. Emmy bought a defunct girls camp, for a quick turnover, but immediately ran into the environmentalists, thus eliminating any expected profit; restrictions, ya know. Emmy looks well, and says that Christine is, too, but, very tired of cooking for visitors, large and small. Am always glad to see Emmy, especially if I am getting too optimistic. Emmy can cure that in nothing flat. Hasta La Vista, Emmy. Vaya con dias. . . . Golly, I have a brand new correspondent, **Allen C. Vaughan**, Course III. Allan allows that he is still alive and kicking; I inferred that if only because he wrote me. He is nothing if not brief, when he says that he is retired as Director of Metallurgical Research, for U.S. Smelting, Refining, and Mining Co.; now U.V. Industries. Now taking life rather easy, with occasional visits to his daughter in Los Angeles. Well, Sir, I find no harm in asking so I asked Allan for more detail, with chances 80-20 against. Thanks just the same, Bud, I love short ones, if there are enough of them. . . . Now, this one is from what I choose to call a regular; he writes, generally, on a quadrennial basis, and this I mean, which makes him better than about 50 per cent of my compatriots. This fella is **Harris Thompson**, VIA. Already he corrects me; this one is his first to Ye Sec'y, but, I must be thinking of the Alumni Fund Capsules. I know that I have heard from him, and I sure appreciate his writing the Secretary, even if it is a first. Harris is an entrepreneur, in Power Respirators, for those who are so unfortunate as to be paralyzed to a point where they cannot breathe. However, his main interest is in developing new products. Harris, his good wife, Lee, son Lyle, daughter Joyce, have just returned from an 8500 mile trip, to Alaska, in six weeks; too dang far, sezzee. Withal, I gather that he is not too enthusiastic about such a trip; at least again. This trip, for four, was via a trailer. Plans to ski at Aspen, as he has for 26 years, plus a trip to Arizona and New Mexico. No white water trip this year, but did take one two years ago. It appears that Harris is partially retired, as he has sold 51% of his respirator business to a younger man, ambitious enough to work at it. Many thanks, indeed, Harris. It is a pleasure to report on you and your family. . . . Now, I must report on the Alumni Officers Conference, held in early September. Seven 33ers registered. If George Ropes was there, no one saw him. I visited with **Westy**, **Ellis Littmann**, **Guido Garbarino**, while they ate their box lunch. No luncheon this year on accounta the Custodians and food handlers strike. The box lunch was better than satisfactory, and, the Awards feature, etc., was held in Kresge, and this was most admirably handled. . . . **Bill Barbour** attended, but I saw him briefly as he entered an elevator as I was leaving . . . **Jim Turner** and Edna attended Friday, but apparently could not stay for Saturday. Hence I missed them as I got there Saturday morning. So, six of us made it, which is not too bad a showing. Reports on the conference itself will probably be reported elsewhere. However, the Saturday PM session on "Nutrition" was an outstanding feature, well worth the price of admission.

We have one notice of decease, this time. **Thomas M. Hayden**, MG, passed on June 26, 1974. We have written Mrs. Hayden, as is usual, and if anyone else wishes to, I have the address. Tom was originally class of 1934 but was transferred to us in 1968. No reason given at the time. . . . We have a few address changes, available to the faithful on the usual basis; **Robert H. Gulliver**, **Charles W. Harper**, **Edward L. Jones**. The magic word, this time, is "Caracoles". . . . We have had several comments on 'Abditory", and we invite comments on any and all of them. However, don't send in any new ones, as I have enough to last at least until this game gets tiresome. . . . That's it for this time around. I wish to thank all of you who responded to the distress call, as, for the first time in a long period, I have had to omit some of the late comers, to be used for January, 1975.—**Warren J. Henderson**, 1079 Hillsboro Beach, Pompano Beach, Florida. 33062

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I mentioned last month that I had a letter from **Jim Burke**—as you will see—the result of mention of his name in June. (Sometimes this gambit works quite well). Jim covers a lot of years when he says "Have contributed little to our Class Notes, since graduating in Course XIII-C. Did take in our 30th Reunion, as was then living in Marblehead, Mass. As some of our Classmates know, spent a good bit of time overseas, with long assignments in pre-communist Shanghai, China and Calcutta, India, plus a very pleasant eight years in Boston. All of this was with the old Isthmian Lines, Inc.

"Be that as it may, what prompted me to write these few lines was Rich Richardson's letter in June Class Notes, wherein he reported upon 1934 in Georgia. Having moved down here in April 1970, I have been a resident of Saint Simons Island for over four years. Am an out of town member of the Atlanta M.I.T. Club, but as I seldom get up there, have yet to attend one of their functions.

"Am now embarked upon a second career, real estate, and am an associate broker, here on Saint Simons Island with Glynn Realty. Specialize in the sale of homes and it goes without saying that I shall be delighted to see any old Classmates. The Golden Isles of Georgia are becoming increasingly popular as a retirement place."

Unfortunately, I have to report the loss of another classmate—Mrs. **Nina (Perera)** Collier. She had been living for a number of years in New Mexico and died this past June. I would extend sympathy from all of us to her family.

I have a number of brief notes from Alumni Fund contributions. The first, from **Horace L. Woodward**, sounds almost like he's looking for information himself. He writes, "who remembers Newton C. Fetter, reverend, and family, responsible for the Sunday Evening Club, of the Old Cambridge and of the Brookline Baptist Church; topical speakers at Cambridge Baptist on Sundays; Wednesday night parties at 335 Harvard St.; Hikes-Blue Hills, Echo Bridge, Arnold Arboretum; skiing at Stowe?" If this strikes a responsive note with anyone who might want to write Horace, I'll swap his address for some words about yourself. . . . **Edward W. Comings** says, "I retired as Dean of Engineering (at University of Delaware, R.M.F.) August 3, 1973. Have been Professor Emeritus in Chemical Engineering since January 1, 1974. Have accepted a two year appointment beginning September 1, 1974, as Professor of Chemical Engineering at the College of Petroleum and Minerals, Dhahran, Kingdom of Saudi Arabia.

Another "half and half" is **Eugene F. Magenau**, who writes "have semi-retired to my summer place at Andover, N.H., where I am having fun winterizing the cottage. Doing all the carpentry, plumbing, heating and electrical work myself is quite different from putting it down on paper for others to do." Sounds to us like fun too—just hope the local building inspector doesn't read the *Review*. . . . At least somebody is still working to keep the wheels of progress turning. From **Peter Kalustian**—"Continuing my consultations business in the field of food fats and chemical derivatives. It is now an international corporation and is growing. It involves foreign and domestic clients." Peter's firm is Peter Kalustian Associates, Inc. . . . We missed **Phil Kron** at reunion and now comes his explanations. "Ellie and I are now residents of Florida. Our first full winter here was delightful. We are concentrating on roses, orchids, and golf. We will be back north to the Finger Lakes for June, July, and August. Sorry to miss the 40th Reunion but it came too early—right in the middle of our move north for the summer. The enclosed business card tells about my activity." Unfortunately, Phil, the "enclosed" card never made it as far as me—so send me another one directly and I'll be glad to publicize whatever your nefarious schemes are.

A final, more formal retirement note comes through a release from Marathon Oil Co. It announces the retirement of **Nicholas G. Dumbros** from his positions of Vice President of Industry and Public Affairs on July 1. Mr. Dumbros had been with Marathon for almost 29 years starting in 1945 as an engineer in the economics and statistics department. In 1953 he was made Department Manager and in 1962 named Assistant to the President and Chief Economist for the company. He was elected Vice President in 1967. Nicholas served with the federal government from 1934 to 1945, concluding his career in public service as Chief of the Productive Capacity Unit in the Petroleum Administration for War. As would be expected, he has been active in the professional societies in the petroleum field and has served on many committees and councils relating to the supply of petroleum.

As this is written we are having our first snow flurries, so winter is really coming to New England. When you read these notes, it should be sometime before Christmas, so may I wish you all a happy holiday season.—**Robert M. Franklin**, Secretary, Satucket Rd., Brewster, Mass. 02631; **George G. Bull**, Assistant Secretary, 4961 Allan Rd., Washington, D.C., 20016

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Twenty-two of us met at the Faculty Club for dinner on October 18th to start our 40th Reunion plans and to hear **Hal Bemis** present his ideas on the 40th reunion gift. Hal is Chairman of the 40th Reunion Gift Committee. We set a goal at our 30th of $1½ million by our 40th and we are two-thirds there. We will all be hearing from Hal very soon on the details of his program to raise the balance. . . . **Rufus Applegarth** is our 40th Reunion Chairman and will have **Ned Collins** as his assistant in the Boston area. Alumni Day will be June 6th, a Friday. We want to have as many of you come as possible so plan now and set those dates aside. Then contact all your '35er friends and be sure they are coming too. The time coincides with Boston's Bicentennial celebration so there are many things going on and a great program will be in store for us. Details will be coming by mail. . . . As newly appointed Nominating Committee chairman I have added **Prescott Smith** and **Peter Grant** to the committee. We are interested in learning who you think should be our officers for the next five years. Now is the time if you wish to be heard. PLEASE WRITE.

The Fourteenth Annual Class Golf Championship was decided by mail between **Ham Dow** on the West coast and **Al Johnson** in the East. The winner was Ham Dow who put together one of his superior rounds which he always seems able to do when the chips are down. Did you realize that our runner-up, Al Johnson, is a registered pharmacist and has been for over 35 years? He and his brother own Johnsons Pharmacy in Keene, N.H. Al says, "Prescriptions at a discount."

Among the notes received through the Alumni Fund Office: **Ken Finlayson** writes, "V.P. Sales, Day & Zimmermann. Have one wife (Lucy), two children, three grandchildren—all great." . . . **Joseph S. Oldham**'s note say he is now working in the Old Colony Cooperative Bank and the Newport National Bank in Providence, R.I. . . . **Arthur Greenblatt** advises "Now in antiques business with shop in Amherst, N.H., specializing in glass paperweights and American silver." . . . **Charles W. Perry** writes, "On April 1st took early retirement from Witco Chemical Corp. to become special projects assistant in the Energy Resources Dept. of the Federal Energy Office in Washington. . . . **John D. Seaver** who makes his home in Lincoln, Mass., told me recently on the phone that he has just retired "completely" after eight years of consulting in the area. . . . **Irving Banquer**, also on the phone, is now living with his wife in Heritage Village, Southbury, Conn. They sold their Waban home and moved down seven months ago. He is active in a splinter group of the Appalachian Mountain Club that goes hiking every Wednesday and Friday. He is also getting heavy use of the woodworking shop in the development and says "the days aren't long enough." . . . **Donald Fenton**'s son James is in the freshman class at M.I.T.

I am sorry to have to report the deaths of three of our former classmates: **Arthur Croxson, Jr.** in Neenah, Wisconsin, on May 17; **Charles S. Taylor** at St. Simons Island, Georgia, on October 8; and very belatedly, **H. Montgomery Baker** at San Francisco in Sept., 1971. On behalf of the Class I am extending our deepest sympathy to the surviving members of the families—**Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

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In *Chemical and Engineering News* for September 9, under People, I found this tidbit which I quote in its entirety: "**Albert J. Klemka** rejoins Morgan Adhesives, Stow, Ohio, as Vice President of Corporate Planning and Development." . . . **Walt Mathesius** was appointed Manager of Engineering for the General Refractories Company's U.S. Refractories division in Pittsburgh as of last July first. Before joining this company, Walt had been a staff engineer with the Koppers Company. . . . *The New York Times*, in August, report on "**Bunkie**" **Knudsen**'s success at revitalizing the White Motor Company—a story some of us have followed with interest. . . . With his contribution to the Alumni Fund (thank you) **Homer Webster** writes from Hawaii that he retired from the U.S. Navy as a Captain in 1957. He had served as a naval aviator since 1936. He now lives on Kauai at Hanalei. . . . At the Alumni Officers' Conference in September, I did not see all those classmates listed as expected but I did come across the **Hibbard Summersgills** in Boston from Longmeadow, Mass., **Eli** and Vivienne **Grossman**, **Bennett Sharp** with his daughter, and the **Elliott Robinsons**. If there were others I am sorry to have missed them. . . . Meanwhile, if you get the urge to write—**Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

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Charles Antoni, Professor of Civil Engineering at Syracuse University, has been named Interim Chairman of the Department of Civil Engineering. Charles was on the faculty at Cornell University and Pennsylvania Military College before joining Syracuse University. He is also a consultant to Steel Bleachers of Erieville Bleacher Co. . . . President Jerome B. Weisner has announced the second holder of the Department of Civil Engineering's Gilbert W. Winslow Career Development Chair as Professor Erik H. Vanmarcke. This award is made on a rotating basis to an untenured Associate Professor in the Department of Civil Engineering in recognition of outstanding accomplishments in teaching and research. The Gilbert W. Winslow Career Development Chair was established in 1971 as a memorial to the late **Gilbert W. Winslow** who graduated in 1937 and whose degree was taken in Civil Engineering. . . . **Joe Keithley**, President and Chairman of the Board, Keithley Instruments Inc., Cleveland, Ohio, has been nominated for Divisional Director/Divisional Delegate for 1975-1976 of the Institute of Electrical and Electronics, Inc. His new address is 2780 Chesterton Road, Shaker Heights, Ohio 44122. . . . **Bill Bergen**, **Vladimir Haensel**, and **John Lowe, III**, have been elected to the National Academy of Engineering. Bill is President of Rockwell International Corporation, El Segundo, California and has made important contributions to the technology of aeronautics and astronautics. Vladimir is president of the Universal Oil Products Company, Des Plaines, Illinois and has made important contributions to the development of processes for oil refining. John is a partner of Tippetts-Abbett-McCarthy-Stratton, New York, New York and was elected for his leadership in the development and application of the principles of soil mechanics. . . . **Bill Muckenhirn**, Professor of Electrical Engineering at The University of Toledo, has been named acting dean of the U.T. Graduate School. . . . **Charles H. Reed** of New York City, Senior Vice President of the General Electric Company, has been elected to the Corporation of the Institute.—**Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, Mass 02155; **Lester M. Klashman**, 198 Maple Street, Malden, Mass. 02148

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Ascher Shapiro was recently elected to the National Academy of Engineering for his contributions to fluid mechanics research and education. Election to the Academy is the highest distinction which can be conferred on an American engineer . . . **Art Gould** has moved up the ladder one more rung—he is now associate dean of the College of Engineering and Physical Sciences at Lehigh University. . . . Class Agent **Frank Kemp** recently became a Director and Executive Vice President in charge of Administration and Media Services for the Walpert Company. T.W.C. is a rapidly growing company located at Cherry Hill, N.J., specializing in advertising, marketing and public relations. . . . **Al Kilgour** has been named Director of the Utility Marketing Division of Commonwealth Associates, Inc., Engineers, Consultants & Architects. Al lives in Jackson, Michigan where he is an active scouter, serving as Chairman of the Land-o-lakes Council Explorer Program . . . **Don Holloway** recently was appointed Technical Director for the General Split Corporation in Milwaukee. Don will be responsible for direction of all staff activities in the areas of tanning, finishing, and new product research and development. . . . **Boris Boguslavsky** wrote a book *Elementary Computer Programming in Fortran IV*, which was published recently. . . . Lastly, your Secretary was made the Director of Finance at Hurdman and Cranstoun, and is stationed in the National Office of the Firm.

In looking over M.I.T. admissions this year, I discovered that **Ralph Slutz** has gone a long way in populating M.I.T.—son Donald has entered, following brother Robert, 1972 and brother Eric 1974. . . . A public note to Estate Secretary **Dave Wright** and Class Agent **Frank Kemp**: Are you following up your jobs properly? . . . I cannot think of a more remote gift possibility for M.I.T. than one made by **Corny Roosevelt** this year—he gave his collection of over 200 Escher prints to the National Gallery of Art in Washington, with the proviso that should the Gallery (A) wish to dispose of them or (B) should cease to be a publicly supported art museum, then the collection is to be transferred to M.I.T.

Present at the A.O.C. were **Paul des Jardins**, **Lou Bruneau**, **Bob Bowie**, **Don Severence**, **M. D. Parekh** (from India), **Dave Wadleigh** and yours truly. Don was singularly honored by becoming a recipient of the Bronze Beaver and also, as the publisher of the *Review*, was the recipient of a beautiful silver bowl for publishing the outstanding magazine in the field. Don has also changed Institute positions from Executive Vice President of the Alumni Association to Director of the Resources Development Office. The Class, I'm sure, wished you success in your new and challenging assignment.

Roy Hale '50, informed me that long missing **Eugene Hochman** is with the Los Angeles Air Pollution Control District. That's all the info I've gotten so far on a long silent member. . . . **Norm Leventhal** was not able to get to A.O.C. since he suffered a back injury and had been bed-ridden. He did say that plans are being formulated for the 45th Reunion. (I'm still suggesting Hawaii). . . . Speaking of Hawaii, **Bob Gordon** is Vice President of Castle and Cooke, one of the original five companies, and is doing much travelling between Hawaii, Central America, the mainland and the Far East in the pineapple, sugar, tuna, banana, macadamia nuts, etc., interests of the company. We seem to get together about once every year or so for a drink of scotch and olives (don't knock it until you try it). . . . **Dave Morse** is now a staff architect for the city of Boston. . . . **Walt Kaufmann** is Vice President in charge of the wire mill of Paulson-Webber in Sunbury, Penn. Walt and Ruth's home overlooks the golf course of the Susquehanna Country Club in Shamokin Dam which is across the Susquehanna from Sunbury. Believe it or not, but he lives on Easy Street.

My familiarity with that part of the world is two-fold. First, I was born not far from there and spent my first seventeen years in that area until matriculation at Tech. Secondly, my son Ed, class of '65, and his family have settled there. Ed is practicing law in Sunbury after being graduated from the University of Pittsburgh Law School last May and after receiving his B.S. (XVI) and M.S. (Sloan) from the Institute. So Henrie and I spent the first two weeks of September prior to the A.O.C. revisiting the old hometown, becoming better acquainted with our first grandson, and generally having a nice vacation.

Mary and **Ben Thompson** are the proud owners of a Cessna 310B, are both instrument rated and do a lot of traveling in the West and Midwest. Ben retired from Hughes about two years ago but went back to work for Aeroject in Azusa. The rest of the Class who reside in this area don't seem to cross paths with me and, hence, the paucity of news. That's about all for now. Best regards.—**A. L. Bruneau, Jr.**, Secretary, Hurdman and Cramston Penney Co., 140 Broadway, New York, N.Y. 10005; **Harold H. Strauss**, Assistant Secretary, 604 19th Street, Santa Monica, Cal. 90402

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Aletta and **Bob Touzalin** announced the marriage of their daughter, Molly, to Robert John McCullough. With one daughter married off in each of the last two months, Bob and Aletta started their autumn vacation in the Carolinas and New England. . . . Mary and **Jim Barton** have started a month's trip to take them through Europe as the fall rains come to the Northwest. . . . **Al Schreiber** has his own company, Western Electronic Products, San Clemente, Cal. and has wedged trips to Costa Rica and Mexico in between school advisory and civic planning works. . . . **Bob Toppin** has been named Vice-President, Manufacturing, of The Fafnir Bearing Co., in New Britain, Conn. . . . **Ben Badenoch** is President of Temescal Division of Airco, Inc. which makes vacuum equipment using electron beam technology for depositing thin films. Ben's hobby is soaring and he welcomes visits from high fliers.

Election to the National Academy of Engineering is one of the highest professional distinctions that can be conferred on an American engineer. It honors those who have made important contributions to engineering theory and practice or who have demonstrated unusual accomplishments in the pioneering of new and developing fields of technology. **Roy Washington Carlson**, Consultant, Berkley, Cal., was elected for his contributions to materials research and invention of devices for measuring stresses, deflections, and pressures. . . . **Harold Chestnut**, Consultant, General Electric Company, Schenectady, N.Y., was elected for his contributions to the theory and practice of control systems and systems engineering. . . . **Robert Plunkett**, Professor of Mechanical Engineering at the University of Minnesota, was elected for his contributions to experimental and analytical mechanics to solve noise, vibration, and fatigue problems.

Jerome Gross, Professor of Medicine at the Harvard Medical School and a biologist at Massachusetts General Hospital, was elected to the National Academy of Sciences for his distinguished and continuing achievements in original research. . . . **Norbert L. Kusters** has been presented the Morris E. Leeds Award by the Institute of Electrical and Electronics Engineers, Inc., for inspiring leadership in the field of electrical measurements, and in particular for the development of the current comparator and its associated applications.

From the newspaper we learn of the death, on June 13, in Cicero, Ill., of **George Donald Lukes**, former Defense Department scientist and White House aide. Mrs. Lukes resides at 3524 Woodbine Street, Chevy Chase, Md.

Myle J. Holley, Jr., Professor of Civil Engineering at M.I.T., has retired after having served since 1947 on the faculty. . . . **G. A. Morrell, Jr.** reports that he is a Development Engineer for materials handling and construction equipment at Clark Equipment Co., Cassopolis, Mich. . . . Because we all enjoy our special kind of news as it is published in *Technology Review*, and because we all know how inflation is increasing problems, the thought occurred to me that some of us are in a position to provide constructive help to the *Review* by encouraging our advertising departments to buy some space. Why not mention to your advertising chief that the *Review* has proved to be an effective medium for recruiting engineering and management personnel?—**Hal Seykota**, Secretary, 14650 Island Drive, Jacksonville Beach, Florida 32250

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The first item of interest is that **Jim Rumsey** has agreed to be Reunion Chairman for the 35th Reunion. His wife Jane will act as his able assistant. His address is 809 Westover Road, Wilimington, Delaware 19807. Anyone who has any ideas to help make the reunion a success should contact Jim.

It is with regret that I must report the death of two classmates: **James E. Watkins**, who was a member of course 6, died on March 22, 1974. Jim had lived at 199 Richmond Avenue, Amityville, New York. . . . **Jack Danforth** enclosed an obituary from the *Boston Globe* on July 29, 1974, of **Richard Lawrance** who was in course 6. "It was evident at an early age that Richard Butterworth Lawrance was interested in electronics. He was awarded an amateur radio license when he was 14 to operate station W1JVL. He later would earn his bachelor's degree in electrical engineering from M.I.T. and in 1950 he was awarded his Ph.D. in physics. Mr. Lawrance, 54, of Highland Avenue, Winchester, died Friday of brain cancer at a Plymouth nursing home. At the time of his death he was the manager of magnetic equipment engineering at Digital Equipment Corp. of

Maynard. He was born in Akron, Ohio, and attended schools in Acton and Kingston before entering M.I.T. Mr. Lawrance was considered a leader in the electronics field and was one of the developers of LORAN (Long Range Navigation). During much of World War II he worked at M.I.T.'s Radiation Laboratory, and he was an instructor in electrical engineering at M.I.T. from 1940-1941 and an instructor in physics there from 1945-1952. While at M.I.T. he was also active in building stage equipment and developing the drama group, the M.I.T. Staff Players. He had also worked for several other firms including, National Research Corp., Honeywell, and the Radio Corporation of America. Mr. Lawrance was a scoutmaster in both Cambridge and Winchester and was a member of the Winchester School Committee for five years and a town meeting member there. He maintained an interest in short wave radio which dated back to his first homemade transmitter, and he could play both flute and bagpipes. He leaves his wife, Frances (Tewksbury), two sons, Jonathan and Peter Lawrance, and a daughter, Wendy Lawrance, all of Winchester."

Norman L. Laschever, Manager of Planning, RCA Aerospace Systems Division, has been appointed Chairman for the 28th Northeast Electronics Research & Engineering Meeting to be held October 29-31 at the Sheraton-Boston Hotel (due to a logistics problem it is assumed the meeting was held since the class notes had to be prepared at a prior date.). . . . **Ed Pollak** is the writer of the forward to *A Guide to Water Cleanup Materials and Methods* recently published by Arthur D. Little. The Guide is an extremely timely publication with the present and long term future concern with environmental problems. . . . **Sam Goldblith**'s title has changed slightly. He is now Underwood-Prescott Professor of Food Science in Department of Nutrition and Food Science and Director of Industrial liaison at Tech. . . . For those of you who only read the class notes column in *Tech Review*, **Tom Creamer** is now a member of the M.I.T. Corporation. Tom, who is Executive Vice President of the First National City Bank of New York was elected by the alumni members. . . . Several of our classmates have relatives who are freshman at Tech this year: Bob Arellano's ('31) nephew Michael and George Chappell's nephew. . . . **Otto Arnold** has been named head of the recently formed Tactical Communications Department at the MITRE Corporations Systems Division. . . . **Tom Jones**, who recently retired as President of University of South Carolina is Visiting Professor of Engineering and Education at Tech for the forthcoming year. He will work with programs in the new Division for Study and Research in Education. At the end of that time he will return to the University of South Carolina as Distinguished Professor of the University to teach and do research on teaching and learning.

There are a number of welcome notes. **Barry Taft** who is President of Dixie Metals, Inc. at 300 Lemon Lane, Casselberry, Florida writes: "Still making a living with my own business. We have diversified a little but our main work is still in lead products, fishing sinkers, wheel weights, etc. Did manage to get a patent on my die casting machine. Am a P.E. in Florida and occasionally do some consulting. We hope to make 35th." . . . **Jim Moore** advises, "Left industry in December 1969 to teach. Am now an Associate Professor in Environmental Sciences at North Shore Community college, Gilford, N.H. Received a Master of Liberal Studies from B.U. in 1971." **Ed Di Giannantonio** advises: "Assistant G.M. Edo Corp., Washington Office, high concentration on energy programs as well as all DOD programs. Very active in M.I.T. Associates program." . . . The final note is from **Bob McKinley**: "Engaged in long range planning for ASTM and for Bower Hill Church in my spare time. At P.P.G., am wrestling with energy and consumer safety problems." . . . As a reminder, start making plans to attend the 35th Reunion in June, 1975. Write to me.—**Al Guttag**, Secretary, Cushman, Darby & Cushman, 1801 K Street, N.W. Washington, D.C. 20006

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When the boxes of old clippings back to January 1960 arrived it was a traumatic experience, but with that behind me I've been digging into the pile—there's no question our classmate **Howie Samuels** has had the greatest exposure and we hope he continues his political candidacy. . . . Forty-oner's seem to be getting to the Presidential age. Here are some from the releases we've received: Dr. **Alan E. Surosky**, President and Chairman of the Board, Science, Engineering & Analysis, Inc.; **E. Kirkbride Miller**, President, T. Rowe Price Growth Stock Fund; **Ray G. O'Connell**, President, Torrington Company; **Stanley E. Webber**, President, Litton Industries Electron Tube Division; **Teddy Walkowicz**, President and Chairman of the Board, National Aviation Corporation; **George W. Clark**, President, Illuminating Engineering Society—an organization of over 10,000 members.

Then there are news of Directors; **Jack Steiner**, V.P. of Boeing as Director of Peoples National Bank of Washington; **Reid Weedon**, Director T. Rowe Price Growth Stock Fund; **Lloyd Perper**, President of Board Trustees Arizona Desert Museum. . . . Now for Personal Briefs: **Robert Fletcher** retired as Chief Scientist, U.S. Air Force Weather Service and is now enjoying golf and life in Arizona; **Will Mott** has started Nuclear Marketing Consultants as of our last communication; **Ralph Delano** is working with I.B.M.; **Bill Stuart** is Dean of Technology at Niagara College in Welland, Ontario; **Jim Thornton** took three months leave of absence to organize political forces in New Jersey; **Robert W. Blake** with Pan Am has some exciting visits to Liberia, Zaire, St. Petersburg, etc.—wherever Pan-Am flies!. . . **Sam Fry** with Boeing is also a high flyer—he climbed the 19,000 ft. Mt. Kilimanjaro in Africa and a 17,700 ft. peak in the Andes. He is President of "The Mountaineers" and is updating the book "Mountaineering—Freedom of the Hills". . . .**Leona Zarsky** has three children in college at one time—Yale seems to be their favorite; **C. D. Arguelles** '41 is a designer of some of Manila's finest buildings; **Charlie King** is Director of Engineering for a N.A.S.A. Test Project and is learning Russian; **Louise Houssiere Herrington** is teaching French in Jennings, La. Her daughter, Dawn, is a nationally-ranked tennis player; **Bill Kussmaul**'s son William III is attending University of Pennsylvania Medical School; **Joe Dietzgen** and his wife Peg attended the 26th M.I.T. Fiesta in Mexico.

I've dug into the pile enough for this month. Send in any news or just let us hear from you.—**Henry Avery**, USS Chemicals, 2873 Grant St., Pittsburgh, Penn. 15230

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While still cleaning up last spring's graduations, **Bernie Levere** wrote that his son David graduated from Harvard College and is now attending Harvard Law School. Bernie's daughter, Peggy, graduated from Teaneck High School and is now attending Wellesley. . . . **Joe Boltinghouse** is still working in Inertial Instruments Engineering at Rockwell International's Autonetics Division. . . . **Dick Russell** was promoted to General Manager of Michigan Seamless Tube Company's South Lyon, Michigan plant. . . . **Maurice Katz**, President of Jecon Metals Corporation, has been elected a Director of Valley Bank and Trust Company in Springfield, Mass. . . . **Charlie Smith**, Chairman of the Board of the U.S. Chamber of Commerce, was the featured speaker at the Iran-American Chamber of Commerce's summer meeting.

Bob Rines, the only law school dean in our class received an Honorary Doctor of Jurisprudence Degree from New England School of Law. Bob is still hot after the Loch Ness Monster and his Edgerton underwater flash picture is the most solid evidence to date. Colonel **Frederick M. Dierks** has retired, having climaxed 40 years of public service with the last seven as Associate Director of National Ocean Survey, Aeronautical Charting and Cartography. Fred and Kathryn reside at Fairfax, Va. . . . One more class of '42 offspring registered at Tech this September—**Tom Crowley**'s son Tom.

News from all of you is few and far between. A beautiful autumn has just set in here in New York and with publication deadline schedules being as they are, a Merry Christmas and Happy New Year to all.—**L. K. Rosett**, 191 Albemarle Road, White Plains, New York 10605

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Angel "Tony" Del Valle and his charming wife Carmen telephoned me early in October from Los Angeles, where they were spending a few days at the start of a round-the-world tour with the Puerto Rico Wine & Gourmet Club. Tony reported that this trip was made possible partly because his son Manuel, who received a S.B. at M.I.T. and an M.B.A. at Harvard, has joined him in his business organizations in San Juan. . . . **Stanley M. Proctor** of Cleveland was named to a six year term on the Board of Trustees of Hiram College. . . . **Leo Feuer**, President of the William Carter Company of Needham Heights, has been renamed to the Board of Directors of the American Apparel Manufacturers Association, Arlington, Virginia, the nation's largest and most active trade association representing the apparel industry. . . . **William I. McKay**, who was a G.W.S. student with our class, has been named Senior Vice President and General Manager of Fluor Engineers and Constructor's Los Angeles Division. . . . **Bill Holway** of Tulsa, Oklahoma, has concluded a one year term as President of the American Consulting Engineers Council. He was a delegate to the annual meeting of the International Federa-

tion of Consulting Engineers in Cape Town, South Africa this fall.

John Linvill, Professor of Electrical Engineering at Stanford, was named a Fellow of the American Academy of Arts & Sciences. . . . **John P. Longwell**, who received his Doctor's degree with our class, was awarded the Sir Alfred C. Edgerton Medal by the Combustion Institute, at its symposium in Tokyo in August of this year. Cited for his distinguished continuing and encouraging contributions in combustion science. Dr. Longwell was the first scientist engaged in industrial research and development to receive the award. He is senior scientific advisor for Exxon Research and Engineering Company in Linden, New Jersey. . . . **Dick Adler** was appointed the Cecil H. Green Professor of Electrical Engineering at M.I.T., where he has been a professor for many years. He is the third person to hold this chair, which was established in 1970 by M.I.T. alumnus Cecil H. Green to help individual members of the Department of Electrical Engineering to move into new areas of research. . . . One of the new coeds at M.I.T. this year is Sharon L. Pastoriza, who is the niece of **Hugh G. Pastoriza, Jr.**, and **Howard Bollinger**'s wife (Hugh's sister) Dorothy. . . . These notes will reach you just before Christmas and so I wish all of you a happy holiday season.—**Richard M. Feingold**, Secretary, 3757 State Street, Santa Barbara, Calif. 93105

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Merry Christmas is the proper salutation yet it seems unusual to make such a statement in mid-October. Congratulations to **Jep Wade** on being returned to the M.I.T. Corporation for another five years. Jeptha, a partner with Choate, Hall & Stewart since 1960, has been a member of the Corporation Executive Committee since 1972. He has also served as a member of the Corporation Development Committee, the Joint Advisory Committee, and the Visiting Committees for Civil Engineering and for Humanities, of which he was Chairman. . . . In June, **Jim Hoaglund** was named President of the McQuay-Perfex, Inc., a Minneapolis-based manufacturer of air conditioning and industrial heat transfer equipment.

In April, **Richard H. Battin** of the Charles Stark Draper Laboratory was elected to the National Academy of Engineering for his contribution to the technology for control, navigation, and guidance for Apollo missions. . . . **Robert B. Roth**'s son, James A., is a member of the Class of 1978. . . . **Raymond A. Dexter** was recently appointed Coordinator for Chaplain Activities on the Alaskan Pipeline. . . . Prof. **Emmet E. Day** was elected President of the Society for Experimental Stress Analysis for '74-'75 at the annual meeting in Detroit last May. S.E.S.A. headquartered in Westport, Conn., is the world's leading technical society for experimental and theoretical mechanics. . . . **Don Kuehl** of Manchester, Conn. is now working for Composite Materials Corp., an ALCOA subsidiary, as Manager of Applications Engineering. . . . **William A. Loeb** is now living full time on a farm in West Stockbridge, Mass. No, Bill has not retired—in fact, he is with Combustion Engineering's Nuclear Power Division in Windsor, Conn. . . . In March, **Homer D. Eckhardt** joined Rockwell International in

Helping Business Tell Its Story: Better Understanding, More Profits, and the Multinationals' Services

Charles H. Smith, Jr., '42, became President of his father's business—the Steel Improvement and Forge Co. of Cleveland, Ohio—less than a year after he earned his S.B. degree in business and engineering administration at M.I.T. Now, more than 30 years later, his company has grown into SIFCO Industries, Inc.—of which he is Chairman of the Board and Chief Executive Officer—and Mr. Smith's confidence in the American system of free enterprise is so outspoken that he's just been elected to a one-year term as Chairman of the Board of Directors of the Chamber of Commerce of the U.S.

His self-assigned mission for the year is to help business put its story across to the public. "I feel that the time has come for a vigorously renewed effort to get the fundamentals of the importance of a free economy across," Mr. Smith says. "Once a free economy goes, freedom goes with it.

"And this is something many Americans don't understand."

A "Massive" Need for Capital

Another issue which Mr. Smith wants to bring to the public: "Our productive capacity has not grown fast enough to keep up with demand."

"Our present shortages," he told the Cleveland Kiwanis Club late this spring, "are all traceable, in one way or another, to insufficient productive capacity.

"The time has come for the nation to realize that the shortages that now appear to so seriously impair the future of our economy will not be eliminated without a massive investment in new sources of production." And this, said Mr. Smith, "will just not occur until real profits reverse the steady decline that has typified the last several decades—until profits are restored to a level that will encourage capital accumulation for the tremendous job ahead."

How big is that job? According to General Electric Co., said Mr. Smith, electric utilities will have cumulative capital needs of over $2.1 trillion between now and the year 2000. The Chase Manhattan Bank proposes, he said, that capital requirements for energy development will be $1.35 trillion by 1985. An oil refinery alone requires a $200 million investment.

To make such funds available, Mr. Smith wants new economic policies by state and federal governments that encourage—not discourage—growth in real profits, to reverse what he called "a persistent long-term decline in the levels of profits."

Toward International Equality

Metal forging is the principal business of SIFCO Industries, Inc., but its specialties also include electrochemical machining and other materials forming processes. Mr. Smith is also a director of several related companies: Bharat Forge Co., Ltd., of Poona, India; Custom Tool and Manufacturing Co., Minneapolis; Schick Products, Inc., San Francisco; Formmet Corp., Avon, Ohio; and AIKOH-SIFCO Co., Ltd., Tokyo. He has held many posts in the U.S. employer delegation to the International Labor Organization, and he is currently on the I.L.O.'s Committee of Experts on the Relationship Between Multinational Corporations and Social Policy.

His I.L.O. experience has convinced Mr. Smith, he says, that the extremes of wealth and poverty which now exist in the world are the most serous threat to world peace with which we must contend. "Somehow we have to bring progress to the rest of the world or face up to a very, very serious situation. . . . The multinational corporation, as I see it, has done more to bring progress in developing countries than anything else that ever existed, . . . and those who are proposing legislation which would halt the progress multinational corporations have brought to developing countries are flirting with very real dangers for the American people and for the whole world."

His job as Chairman of the Board of the Chamber of Commerce of the US., says Charles H. Smith, Jr., '42 (he is Chairman of the Board of his family company, SIFCO Industries Inc, of Cleveland), is to spread "the real picture about the role of business in providing the jobs and the goods and services we all want and need; about the relationship between profits, investment, and jobs . . ." Mr. Smith will hold the top job in the U.S. Chamber of Commerce for a year; in his acceptance speech he told his colleagues that "it is the free market place that has proven to be incalculably more efficient than anything else ever devised to allocate resources in a manner that comes closest to fulfilling the needs and desires of the public. Yet today," he warned, ". . . the basic freedoms that have made our nation great are being compromised in a way that could . . . destroy our free economy long before my grandchildren are old enough to enjoy it." (Photo: Reni Newsphotos, Inc., from the U.S. Chamber of Commerce)

Hopewell, Mass. as an Research and Development engineer in the Textile Machinery Division. . . . In early May, **Richard C. Winkler** was elected Senior Vice President of Container Corporation of America, a Chicago-based packaging company. Dick joined C.C.A. in 1946, was elected a Vice President in '66, and in 1973 moved to his most recent post as Vice President and General Manager of the Central Shipping Container Division.

In late July, **Art Miller** wrote from N. A.S.A.'s Space Flight Center in Beltsville, Maryland, advising that he was celebrating the 10,000th orbit of an orbiting telescope, the launch of which was detailed in the January '73 issue of the *Review*! After a weekend of celebration and prayers for another 10,000 orbits, Art returned to Princeton to determine why the rascal stayed up! . . . Alumni Days 1974 attendees were **Charles Hart**, **Don Lovell**, Committeeman **Bob Magiathlin**, **Art Miller**, **Warren Miller**, **Charlie Patterson**, **Jim Pickel** and yours truly! Yes, the guys for the most part took their wives to Pops! . . . While on the subject of Alumni Day, Pops, and the like, we would hope that you will—by the time you read these notes—have received a 35th Reunion mailing. At this very moment there is confusion as to when Pops will occur. Be that as it may, we trust you and yours will participate in 45's 35th at Chatham Bars Inn on the Cape and the M.I.T. Campus in Cambridge sometime between Thursday, June 5 and Monday, June 9.

As an Alumni Fund Board member may I personally thank all givers and workers for their part in the 1974 Fund; special thanks go to **Bob Magiathlin** and **Maxie Ruerhmund** as class activists as well as **Bill Shuman** and **Spence Standish** in the Leadership area and **Don Strang** and **Curt Beck** in Regions. . . . Again, a Merry Christmas to all—and a white one to those of us in the North, especially for Lou and **Pete Hickey** now back in Massachusetts (Topsfield) after 20 years in Jersey.—**Clinton H. Springer**, Secretary, Box 288, New Castle, N.H. 03854

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Mail is rather sparse this month but **Herb Schmidlin** advises that he is now Plant Manager of the R. M. Roll Products Co. division of Raybestos Manhattan plant in Neenah, Wisconsin. . . . It is interesting to note that **Walt Webb** has a son, Spahr, and **Walt Kern** a daughter, Jill, in the freshman class at the Institute. . . . The clipping services provide some news on our brethren starting off with **Charles Smith** who has been elected Chairman of the Board of the Chamber of Commerce of the U.S. He is also Board Chairman of SIFCO Industries in Cleveland. . . . **Jordan Baruch**, now of Harvard, has been elected to the National Academy of Engineering.

A little different slant has **Jack Greene** retiring to Bakersville, N.C., after twenty-seven years of federal service. He was the Deputy Assistant Director for Research in the Defense Departments Defense Civil Preparedness Agency in the Pentagon. He was also awarded a D.C.P.A. Distinguished Civilian Service Award for his meritorious service. . . . **Ben Ranan** has been named Director of Manufacturing for the Modular Instrumentation Division of Analog Devices Inc. in Norwood, Mass. . . . **Leroy Oberholtzer** has been appointed Engineering Manager for Amana Refrigeration Inc. . . . That's it for this month but have a happy Holiday Season and try to drop me a line.—**Dick O'Donnell**, Secretary, 28516 Lincoln, Bay Village, Ohio 44140

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Frank A. Jones, Jr. has been named President of Cook Industries, Inc. of Memphis, Tenn., a diversified operating company in the fields of agribusiness, building products, structural pest control, and insurance. Frank joined Cook Industries in 1955 after operating a cotton business in Greenville, S.C. Frank was president of Cook's building products subsidiary, E. L. Bruce Co., Inc. from May 1972 to November 1973. Cook also owns several other companies including Terminix International.

Louis C. Rasmussen has been named a vice-president of Kansas City Power & Light Company, Kansas City, Mo. Lou, who joined the company as assistant manager of rates in 1960 and became manager in 1965, will head the newly established Department of Corporate Planning and Economic Controls. In his new position he will coordinate planning and cost control functions, head the data processing activities of the company, and coordinate decisions including long-range corporate planning. Lou obtained a juris doctor degree in 1968 from University of Missouri-Kansas City Law School. He and his wife Cecile have four children. . . . I had the good fortune of taking first term freshman mechanical drawing in the summer of 1945 with Lou, Kemon Taschioglou, **Ben Ball**, and **Bill Boston**. My memories of this class remind me of the nitty-gritty detail, the high standards of performance, and the fun of working with classmates who could accomplish tough assignments which together are part of an M.I.T. education. Other members of this freshman section are encouraged to write me so we can plan a mini-reunion in 1978 at our 30th Reunion.

Sheldon L. Green has been named Vice-President of Hunt's subsidiary, Industrial Dyestuff of East Providence, Rhode Island. Sheldon continues as General Manager of Hunt's Wayland Chemical Division in Lincoln, Rhode Island. . . . **Walter Chaiko** joined Ingersoll-Rand Research in Princeton, New Jersey as manager of research and development contracts. Walter has been assigned the mission of building the company's involvement in government sponsored research and development, especially in energy related areas. . . . **Joseph V. Yance** has moved to Washington and is working for the Environmental Protection Agency. I suggest you look up Marshall Dick '48, who is also at E.P.A.

Ezra Garforth, Jr. is now in management consulting specializing in executive search and mergers/acquisitions. . . . **John Kail Crane** was installed as President of the Chicago chapter of the Illinois Society of Professional Engineers. . . . **Eugene D. Purdum** has four children in college this year. Since 1973 he has been a member of the new structural design and consulting organization, Olsen, Purdum, and White, Inc. . . . **Donald Towse** was appointed to the Earth Sciences Staff, Lawrence Livermore Laboratory, University of California. Don is working on gesthermal resources development, particularly evaluation and testing of the resources in Imperial Valley of California. . . . **William N. Papian** has joined Claxton Walker and Associates as Vice-President and Chief Engineer. The firm is in Potomac, Maryland.

L. C. Rasmussen, '48

John Gilchrist is doing freelance writing and editing in various aspects of laboratory and clinical medicine. John wrote from New Haven, Conn.

Of this year's entering freshmen ten students are related to members of the class of '48. Bill Hunt of Glens Falls, N.Y. and **Bob Brown** of Reading, Mass. have daughters at Tech—Maureen Hunt and Patricia Brown. . . . **Dennis Allegretti**, **Herb Kindler**, **John Little**, and **Herb Schneider** have sons in the freshmen class—Greg Allegretti, David Kindler, John Little, and Tom Schneider. . . . Others in the freshman class: **Jim Pastoriza**'s niece Sharon Pastoriza and **Charles Ostrom**'s niece Barbara Ostrom. . . . **Walter Mellen**'s nephew Donald Mellen (Walt's father was Class of '16.) . . . **William Russell**'s daughter Rita Russell. Rita's uncle Father **Domenic Silvestro** was also Class of '48.

Last spring, **C. Vincent Vappi**, President and Chief Executive Officer of Vappi and Company, Inc. of Cambridge, Mass. was elected to the Board of Directors of John Hancock Mutual Life Insurance Co. Vince is Chairman of the Board of Technical Operations, Inc. of Burlington, Mass. which acquired Vappi & Company in 1971. . . . **Arthur H. Kuljian**, formerly President, is now Chairman of the Board of the Kuljian Corporation, international engineers and constructors in power, industry, transportation and public works. Kuljian's headquarters are in Philadelphia, Penn. Art will be in charge of all technical functions concerning engineering, construction and computer services. The new President will be responsible for all business functions concerning sales, finance, and public relations.—**S. Martin Billett**, Secretary, 16 Greenwood Avenue, Barrington, R.I. 02806

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Professor **John G. King**, distinguished teacher and researcher in the Department of Physics at M.I.T., has been named M.I.T.'s first Francis Friedman Professor of Physics. The Friedman Professorship is named after a much beloved and outstanding young faculty member, active in improving the

How to Stay in the High-Technology Market

It has always been our most important natural resource—not oil, not coal, not iron and copper, but the flow of marketable technology. Its consistent contribution is new jobs, new companies, new competition. We cannot cut back, or stand still . . . the flow must be sustained.

"Technology utilization is the power that enables us to keep our place in the world", said Daniel J. Fink, '48, President of the American Institute of Aeronautics and Astronautics, in an address June 25 to the National Press Club. Some of his thoughts:

The Space Act of 1958 gives the National Aeronautics and Space Administration "no mechanism to bring technology to the marketplace, either by direct transfer or by adaptation or by spinoff. The Space Act *does* direct N.A.S.A. to make technology available to the market through education and dissemination, but these are communication processes only." On its own initiative, N.A.S.A. developed and demonstrated communications satellites and prepared to transfer them into the private sector, and this was made possible when Congress created an institution (COMSAT Corp.) to preside over this new industrial beginning.

We succeed best when technology is transferred directly, in this manner. Other examples are the jet engine and the meteorological satellite. An appropriate institutional arrangement is absolutely necessary to "bridge the gap between mere technical feasibility and complete viability in the marketplace". When we haven't provided this bridge, federally sponsored research and development often does not reach the commercial and social marketplace.

Keeping Technology Out of the Market

But only about one-quarter of one percent ($43 million out of $17 billion) of the federal research and development budget (according to a recent National Academy of Engineering study) is provided to stimulate the utilization of technology. Education and information functions are allotted about $1 billion. "I believe, therefore, that it is fair to say that secondary utilization of technology created by the federal government, if not actually inhibited, is certainly not encouraged by existing legislative and fiscal policy."

Five examples of obstacles to the use of technology in viable products and services in the commercial marketplace or as working tools in the public sector:

1. Technical risk. "Which engineer manufacturer would have been prepared to develop the jet engine from the ground up, not knowing whether or not it would ever work?"
2. Market risk. It is possible that a technically feasible innovation will bring no profitable production—if the market proves to be too fragmented.
3. Timing. Entrepreneurs must try to guess *when* their investment will become big industry . . . a wrong guess can mean disaster.

Daniel J. Fink gave an address June 25, 1974 at the National Press Club.

4. Cost. "In the case of atomic energy, the whole electric power industry combined could not have paid for its development."
5. Jurisdictional obstacles. Technology utilization can be inhibited by legal roadblocks—domestic use of communication satellites was affected, for example, until the F.C.C. eliminated legal obstacles. A high-speed urban transportation development is likely to be scrutinized by the Departments of Health, Education and Welfare, Housing and Urban Development, and Transportation as well as a number of boards and commissions and state, county and municipal bodies before use in the public sector.

Needs: Money, Manpower, and Institutions

To remove such barriers to the utilization of technology requires dollars, not talk, as well as manpower, resources and creative institutions to achieve accommodations between government and industry.

What should be done to reduce skepticism and disillusionment and improve our chances of using advanced technology for social good?

1. Let government assure the continuance of direct transfer by "keeping the mission pipelines flowing at a steady and predictable rate." Encourage entrepreneurs who through their own initiative and investment bring technology into the marketplace. Maintain the steady pursuit of solutions to our many technological challenges.
2. Emphasize the adaptive engineering stage for every major new technological development with utilization potential. Remember that technology is rarely ready for direct hand-over from a government agency to a user.
3. Continue government sponsorship of research test-beds, with industry carrying on developmental and experimental programs. This also gives small and large businesses a chance to compete on equal terms in advanced technology utilization.
4. Most important: look for creative arrangements to help users take over and capitalize on new technology. Emerging large-scale technology justifies unprecedented institutional relationships. A creative institution is needed to "harmonize the interests of government and industry"—perhaps the government agencies' conflicting interests as well. A major stumbling block in technology utilization, the adversary system, may then be ended. For example, consider the Earth-resources programs: without some new institutional relationship to represent the diverse interests of many potential users, N.A.S.A. will find a community of users without experience or technical resources to competently assume the role of system manager.

Avoiding the Low-Technology Game

"It is time we faced the hard facts about technology utilization and our place in the world. The Council of Economic Advisors says that over half of our nation's growth has been based on our technological leadership. Our Gross National Product level varies directly with the level of our research and development expenditures, according to *Harvard Business Review*. Foreign nations are rapidly closing the gap as their utilization performance improves. It took 20 years to transfer the technology for typewriters, only two years to transfer solid-state circuitry, for example. The National Science Foundation says that in the 1950's we imported about one-tenth of our chemical processes; but by the 1960's the fraction had risen to one-third. Seventy-seven percent of our trade surplus is with the less-developed world. And in low-technology products, we have, as you know, a dramatically unfavorable position."

The utilization of technology is the power that enables the U.S. to sustain its international position. Other nations are advancing . . . we must, too, or "we'll find ourselves competing in low-technology markets, and we simply cannot win in that ball park."

teaching of physics, who died in 1962. The lectureship was made possible by a gift from the O-F Foundation, Inc. In announcing the appointment, Robert A. Alberty, Dean of the M.I.T. School of Science, said: "Through his innovative teaching and his recent research, the most recent example of which is on the molecular microscope, John King has brought a sense of excitement to all his activities at M.I.T. He has also carried this spirit to the many places outside M.I.T. where he has taught." In 1965 Professor King received the Robert A. Millikan Award of the American Association of Physics Teachers "for his notable and creative contributions to the teaching of physics." In 1971, he was one of 10 recipients nationwide of the Harbison Award, conferred by the Danforth Foundation for gifted teaching. More recently he has concentrated his efforts on the development of the "molecular microscope," an instrument that uses neutral molecules to study surface phenomena with spatial resolution. Professor King lives in Woolwich, Maine.

We regret to announce the death of **Joseph James Miano**, on June 22. He was employed as a contract administrator for the Hamilton Standard Company of Windsor Locks. Besides his wife, James leaves two sons, Joseph J. Jr. and Philip A., and a daughter, Andrea A., all at home. He resided in Hartford, Connecticut.

John H. Litchfield, is one of 50 inventors who were honored recently (June 26) for patents they received during 1973 as staff members of the Columbus Laboratories of Battelle Memorial Institute. Each of the patent recipients received a personalized desk plaque during an invention award program that is part of a series planned by Battelle Development Corporation in recognition of inventors at Battelle's research laboratories in Columbus, Ohio, Richland, Washington, Geneva, Switzerland, and Frankfurt, Germany. Dr. Litchfield of Worthington, Ohio, holds a patent on the development of chewing-gum compositions. . . . **Theodore C. Anderson**, is the author of an article entitled, "Testing Long-Haul Carrier Systems Automatically", which was published in the July/August 1974 issue of Bell Laboratories "Record". In it he explains the new system that Bell Laboratories and A.T.&T. Long Lines have developed called the 92A Carrier Transmission Maintenance System. It can perform automatic in-service tests to replace the manual routine measurements. It also offers computer-aided, centralized facilities that greatly enhance one person's ability to isolate troubles within an office and at other locations.

The election of 78 American engineers to the National Academy of Engineering was announced in March. Included among the new members is **Donald Robert Fergusson Harleman**. He was elected for his leadership in the development of theoretical and experimental techniques in the field of fluid mechanics. Election to the Academy is the highest professional distinction that can be conferred on an American engineer and honors those who have made important contributions to engineering theory and practice or who have demonstrated unusual accomplishments in the pioneering of new and developing fields of technology.

The following are 1974 admitted freshman students whose relatives have graduated from M.I.T.: Montgomery M. Alger, Louisville, Ky. Father: John Alger '49; Richard W. Berger, Pittsburgh, Penn. Father: **Lewis W. Berger**; Ross B. Buchanan, Orange, Conn. Father: **Thomas C. Buchanan**; Charles L. Epstein, Elkins Park, Penn. Uncle: **Gerald Peretsman**; Frank R. Field III, North Augusta, S.C. Uncle: **John J. Mohr**; Kenneth P. Kellogg, Forest Lake, Minn. Father: Professor **Paul J. Kellogg**; Eli M. Wylen, Broomall, Penn. Father: **Joseph Wylen**; Frances D. Harrison, Newton, Mass. Father: **Ralph J. Harrison**.

This is to give you your first notification that the 25th Reunion of the Class of 1950 will be held on the campus at M.I.T. from June 5 through June 8, 1975. Please reserve these dates so that you may enjoy your 25th Reunion with your classmates. At our Reunion, we intend to have a series of photographs showing you and your classmates during the school years. If you have any group photos from that period, I would appreciate your sending them to me.—**John T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

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Eugene S. Lubarsky has joined A. Johnson and Co. in New York City as Director of Marketing, after 19 years with Mobil Oil. All of his three sons are attending Lehigh University—one, a pre-med; another in business administration and the third in the engineering college . . . Architect **James H. Ballou** (Salem, Mass.) has been appointed Vice President of the Board of Trustees of the U.S.S. Constitution Museum Foundation. His architectural firm is working on a new museum to be housed in one of the 1826 granite buildings at the Navy Yard designed by Alexander Pariss. They are also busy with restoration in the Salem renewal area and other preservation, restoration-type projects. . . . **Henry Bull** of San Francisco will be taking his wife, Barbara, children Peter and Nina, nine and seven and one-half, to Norway for three months this year. This is a part of a mini-sabbatical program arranged by the firm which employs him. A three month leave is granted every four years and this year it is Henry's turn. He didn't mention the name of the firm—probably concentrating on his travel plans . . . Another classmate already based in Europe is **Ray Gruwell**, General Manager of Ralph M. Parsons branch in Frankfort, Germany, where he has been for the past eight years except for an 18 month stay in London.

Two news items come from men in the military world: **Herbert S. Ainsworth** is Commander of Patrol Wings Pacific Fleet with P3 Orion Squadron based throughout the Pacific Ocean . . . Col. **Francis J. Davis** expects to be at Fort Monmouth, N.J. after three years in Washington, D.C. on the Joint Staff. . . . **Bill Lucas** transferred from Columbus, Ohio to Beaumont, Texas, with Mobil Oil Corporation and is completely renovating an old house . . . **Robert E. Donovan** is Product Engineering Supervisor for the Construction Products Division of the Norton Company in Worcester, Mass. He has a part-time job, he says: "negotiating with various law enforcement agencies about my children—usually involving contacts with local auto junk yards and insurance companies." He reports three hobbies which he coordinated into one operation in the backyard pool last summer, namely, procrastination, beer drinking, and swimming. . . . **Dan Hardie** is in Ann Arbor working for Bechtel Thermal Power Co. as Project Quality Engineer. Family status—Daniel, a pre-med student at University of Michigan; Susan married and living in Florida; Bob at Michigan State University; and Jim a sophomore in high school.

While many of us may have to settle for a shower vocalise now and then, we have a lieder singer in our Class. **Arthur Wasserman**, Manager of Allis Chalmers Electric Vehicle Drive Department in Milwaukee, writes that he still does some singing occasionally. "Last evening the wife of a good friend and I gave an informal concert of Schubert and Schumann Lieder to a group of 25 friends and neighbors in our home. Shades of Tech. Show, the Logarythms and the M.I.T. Glee Club!" . . . **Marc Pearlman**—founder and Operations Manager of Sterling Engineering Construction Co. of Providence, R.I., is now completing a $15 million high school in Taunton, Mass., also small school in Martha's Vineyard, first public building in W. Tisbury in over 100 years. He has a family of four all grown up. . . . **Richard Hoblin**, pastor of First Congregational Church in River Falls, Wis., since 1970, is also Moderator for N. W. Wisconsin Association of United Church of Christ and Chairman of River Falls Ministerium and United Ministries in Higher Education. . . . **Walter E. "Mike" Johnson** has been appointed a Trustee to the Board of Officers and Trustees of the American Society for Metals. Since 1967 he has been Manager of Metals Application and Evaluation for General Electric Co.'s Major Appliance Laboratory in Louisville. He joined G.E. in 1960 and was granted the General Electric Management Award in 1971. His activities in the Society have been many and varied and in 1970-73 he established technical activities for the Materials System and Design Division. In addition, he is past President of the American Deep Drawing Research Group and a member of MENSA. . . . **James Friend** dropped us the following note: "After N.Y.U. closed the School of Engineering and Science at University Heights, Bronx, and with it the Department of Meteorology and Oceanography, I came to Drexel University in the Chemistry Department in September 1973. I am now Robert S. Hanson Professor of Atmospheric Chemistry."

We have received news of two deaths among our classmates. One is **Douglas Jones** of Menomonee, Michigan, who died on August 8, completely unexpectedly, from a case of hepatitis. . . . **Jack Magidson** passed away in May in Westport, Conn. where he had been Distribution & Controls Manager for I.B.M. World Trade Corp.

Gordon A. Rampy has located his business and residence from Nitro, W. Va. to the beautiful "hunt country" of Warrenton, Va. His firm, Chemetrics, Inc. was newly formed in March 1973 and is engaged in the manufacture of water analysis kits. He states that he is enjoying the luxury of professional independence. He reports, what by now has a familiar ring to many 51'ers, that his oldest of four boys is off to college at Abilene Christian College in Texas, and the second one lining up for next year.—**Fred W. Weltz**, Secretary, 4800 S. W. 74th St., Des Moines, Iowa 50321; **Marshall Alper**, Assistant Secretary, 1130 Coronet Ave., Pasadena, Cal. 91107; **Samuel Rubinovitz**, Assistant Secretary, 3 Bowser Rd., Lexington, Mass. 02173;

John Dowds, 1800 N. W. 18th, Oklahoma City, Okla. 73106

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Dear Classmates: Sorry to learn that virtually everybody in the class has been terribly ill with "writer's crampitis." Please get well quick, or I undoubtedly will develop a bad case of same said disease. . . . After a summer in D.C., and a quick week of vacation in St. Thomas, yours truly has returned to the ivory tower and is currently making life difficult for grad students. With teaching, researching and writing, previous little time remains for the more important activities (i.e., wine, women and song). So it goes with dedicated people! . . . **Karl Epple** was recently promoted to Vice-President, Mitre Corporation, duties which he shares with those of being General Manager of Heli-Coil products division. . . . **Wolf (Bill) Haberman** sent a lengthy note, which I shall quote (unedited): "Berma and I have been quite busy raising our three sons and daughter in Framingham and taking part in community activities. My oldest, 19, is a freshman at University of Massachusetts, my second oldest, 17, just returned from a year in Israel with his aunt. Others are 14 and 12. I'm still at Mitre Corp. in Bedford after 13½ years where I'm a Group Leader and Project Leader for military security systems (intrusion detection). Berna teaches emotionally disturbed children in the public schools and is active in the League of Women Voters, among other things. I'm an elected Town Meeting Member and Chairman of one Standing Committees (Personnel). We do a lot of camping, skiing and sailing (the latter learned at Tech) and Berna teaches yoga." . . . **Herb Richardson** was appointed as head of M.I.T.'s Mechanical Engineering Department this summer; other than for a short stint with the U.S. Dept. of Transportation (as its first Chief Scientist), Herb has spent his years since graduation at M.I.T., either as a researcher (from 1953 to 1958) or as a member of the faculty (since 1959). I'm not sure whether we should extend congratulations or condolences, but in any case we wish him well in his new post. . . . Another classmate, **Robert Rivers**, is now President of Aircom, Inc. in Union, New Hampshire and is also a nominee for an office in The Institute of Electrical and Electronics Engineers. . . . **Ronald Scott** has been elected to National Academy of Engineering on the basis of his contributions to the theory and application of soil mechanics; he currently is on the Cal Tech faculty. (You remember *that* school, the one which Lee DuBridge, former president of Cal Tech, referred to as "the M.I.T. of the West" at Julius Stratton's inauguration as President of M.I.T.) . . . **Thornton Wilson**, now Chairman and Chief Executive Officer of Boeing Company, was also elected to the National Academy of Engineering; the basis of his election was leadership in the engineering and management of major complex aerospace systems for commercial and military use. . . . That is ALL the news I have; please do drop me a line or have your wife or secretary do so. Till then, regards.—**Martin Wohl**, Secretary, 1420 Centre Avenue (Apt. 1706), Pittsburgh.

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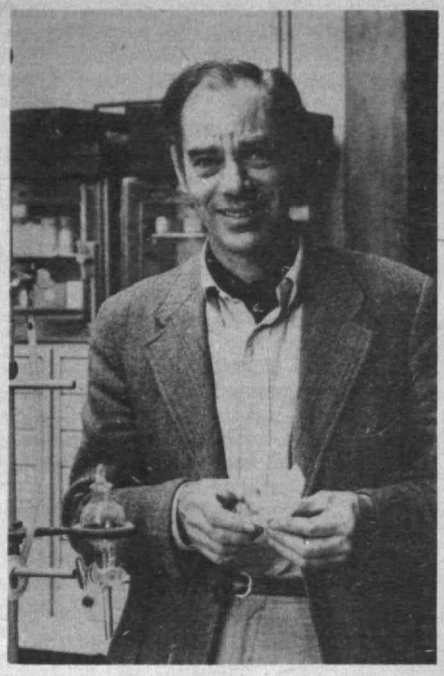
Publish or Perish? Yes, but Scholarship Is not Enough

Should publication of original research be a prerequisite for promotion to a tenured position at a liberal arts college? Dr. Curt W. Beck, Ph.D. '55, Professor of Chemistry at Vassar College, feels "no teacher can remain effective for three decades or more if he *only* teaches". His thesis is that scholarship and teaching are intimately connected. "I find that carrying on research has an effect on my teaching: it keeps me a student". Realizing that progress in his own research is made only slowly and painfully—three wrong steps are made for every right one—"makes the difference between sympathy and empathy. I feel not merely *for* my students, I feel *with* them," he writes in the alumnae magazine of Vassar College. As his publications are "in a way the equivalent of my students' tests and papers, . . . I think I am a better judge for being judged myself."

Professor Beck qualifies his arguments with a warning: "While scholarship, published or not, is a necessary condition of first-rate teaching, it is by no means a sufficient condition. There are many great scholars who cannot teach at all, and any tenure decision on scholarship alone would inflict superior minds upon generations of defenseless students with whom they cannot communicate. The criterion for tenure, then, should be demonstrated teaching ability supported by active scholarship of whatever form."

But time is a fundamental requirement of scholarship—and what if today's economics enforce a rapidly rising student/faculty ratio? "What . . . of my young untenured colleagues who are committed to excellence in teaching as well as to the pursuit of scholarship? . . . They cannot be scholars without neglecting their students, but they will not be given tenure unless they demonstrate scholarship.

"If scholarship is not an idle, ivory-tower luxury but a necessary ingredient of good teaching, then the present policies will not only gravely reduce the opportunities for faculty scholarship, they will quickly lower the quality of teaching as well."



Curt W. Beck

Carl Bohne received the H. W. Sweatt Engineer-Scientist Award for outstanding achievement in 1973. The award was based on Carl's accomplishments in the development of the first cryogenic interferometer spectrometer operating within 10 degrees of absolute zero. . . . **Walter Kocher** is now Vice President of International Airco's Welding Products Division. . . . **Robert Hill**'s consulting business clients include the Jet Propulsion Laboratory and U. C. Berkeley. During his spare time, Bob enjoys backpacking and skiing in the High Sierras. Wife Betsy is in public relations for the Glendon School District, and daughters Barbara and Beverly both attend the University of California.

Edgar Brown, Professor of Mathematics at Brandeis, has been elected a Fellow of the American Academy of Arts and Sciences. . . . **Raymond Mintz**, a Staff Assistant, at the Office of Regulations and Rulings of the U. S. Customs Service, is back at the Institute as a Sloan Fellow. . . . Professor **Jerry Cohen**, Chairman of Northwestern University's Material Science Department, has been named as the first Frank C. Engelhart Professor of Materials Science. Jerry initiated Northwestern's Technological Institute's single-subject intensive academic "block" approach to freshman engineering education. . . . **Bill McTigue** has been named President of the Associated Soil and Foundation Engineers, Inc., a national association of consulting firms. Bill is a Senior Vice President and Treasurer of Haley & Aldrich, Inc. in Cambridge. Merry Christmas.—**Chuck Masison**, **Lou Mahoney** and **Dave Howes**, Box 66, Carlisle, Mass. 01741

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Our Twentieth Reunion Committee is working feverishly to prepare a great festival of commemoration. They have gone so far as to book up a hotel on Martha's Vineyard for 6-8 June in anticipation of hordes of reuniters. So please scan the mails for their messages, and make your commitment. With your help we can enjoy a really good reunion next year.

Ralph M. Shoffner has been appointed director of marketing for Richard Abel & Co., a firm that provides books and services to libraries. . . . **Dave Barnes** is back in southern California after two years in Illinois. He is evaluating business concepts for Xerox. . . . Two new companies have been formed by classmates. **Francis C. Rogerson, Jr.**, is a partner in C. H. Fargo and Co., a real estate brokerage firm in Boston.

Gus Kabeschat founded Kabeschat Construction Co., which is now fully operative with several buildings under construction, including the federal G.S.A. office building in Wilkes Barre, Pa.

Philip Molten has been working to turn undeveloped urban land in Tiburon, California, into vegetable and flower gardens. His plan for urban agricultural land use in the town where he lives has received a lot of favorable attention for its originality. Phil has also changed his hobby of architectural photography into a semi-vocation. He put together a traveling exhibit for architecture schools to give an idea of the possibilities of the professional use of photography, and has taken it to a dozen universities in the past two years. Another classmate who has concerned himself with environmental topics is **Paul Morgenstern**, who co-authored a paper on a strategy for reduction of particulate emissions in the Boston urban area. The paper was presented at the third Urban Technology Conference in Boston.—**Allan C. Schell**, Secretary, 19 Wedgemere Ave., Winchester, Mass. 01890

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First of all, my best wishes for the holidays. . . . **Alar Toomre** has been elected a Fellow of the American Academy of Arts and Sciences. . . . **Norman W. Bryan** was recently promoted to Vice President of Connell Associates, Inc., a 225 man A/E firm in Miami. He is responsible for new business development. . . . **Guy Carbone** has been awarded the Army Reserve Achievement Medal. In awarding the medal, Major Carbone was commended for "his exemplary behavior, efficiency and fidelity while serving as a member of the 1030th Boston USAR School." . . . **Axel Rosenblad** writes that since M.I.T. he has worked in the chemical projects equipment field, first for consulting firms and later as head of his own small corporation outside of Princeton, New Jersey. He and his wife, Patricia, have two boys, age 13 and 11, and are now moving to the shore to be closer to their "Hole in the Water", a small cruising sloop.

Stan Kroder is with I.B.M. in Bethesda, Md. managing education programs for the Federal Marketing Group. Stan moved in 1973 to Montgomery Village in Gaithersburg, Md. . . . **Tom Dwyer** has been named Program Planning Associate in the Lighting Products Division of Corning. Tom, who had been a Senior Project Engineer since last year, joined Corning in 1967 as a Senior Engineer in forming research. In 1970 and 1971 he served at the Paden City, West Virginia plant as Plant Manufacturing Engineer. . . . **Marlin Delson**'s son, David, is a freshman in this year's class at M.I.T. I believe this is the second time that a son of a member of the class has entered M.I.T. . . . The architecture program at the University of Miami, which is administered by **Ralph Warburton**, has recently received accreditation by the National Architectural Accrediting Board and commendation from the Florida State Board of Architecture. . . .

Irwin Jacobs resigned as Professor of Information and Computer Science at the University of California. Irwin is now President of Linkabit Corp., San Diego. He was elected a Fellow of the I.E.E.E. in January of this year. Irwin is past President of La Jolla Democratic Club, Jewish Community of La Jolla, and the Junior High School Citizens Advisory Committee. He and his wife and four sons live in La Jolla. . . . **John Day** is now working for American Microsystems, Inc. as Director of New Market Development. He is currently spending a lot of time in Detroit talking to automobile manufacturers. . . . In February, Betty and I plan to host a little cocktail party at our apartment for those Classmates in the New York area. I hope to telephone many of those in the area but would appreciate anyone reading this notice to get hold of me at my office (212-883-4301) or at my home (212-865-1732) and get the details of time and place.—**Fred L. Morefield**, Secretary, 285 Riverside Drive, New York, N.Y. 10025

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Strolling along Newbury Street one warm evening this summer, I spied **Larry Andrews** entering a restaurant. Larry was in town attending an I.B.M. regional meeting. He has been working for I.B.M. as a marketing representative and gets to Boston occasionally for these regional events. . . . Then, while flying from Chicago, I ran into **Steve Tannenbaum** who was returning to Boston from some consulting assignments in the mid-west. He spent a year's sabbatical in Israel last year and is now back at M.I.T. continuing his research. . . . More travel tales will await another issue. Obviously the best place to gather news of our peripatetic class is in the middle of O'Hare airport!

Robert Wilcox was transferred from the A.E.C. to the State Department and posted to Buenos Aires as Scientific and Technological Attache at the American Embassy. He serves on the board of Directors of the American Community School and is active in the M.I.T. Club of Buenos Aires. . . . From **Mike Balderston** who is still "down under" in Australia comes this bit of cheery economic news: "gas is still cheaper in the U.S. than in Australia, our rate of inflation here is about 13% for retail items in general and 22% for food. The absolute prices of food seem higher too, especially if the exchange rate is considered. Still, there are compensations and if and when we return to the U.S. it will be with many regrets at the friends we'll be leaving."

Richard Nyder has been promoted to Western Regional Sales Manager for E-H Research Laboratories, responsible for the digital instrument and large test systems product lines. Richard and Penny, along with their two children are happily residing in Palos Verdes Estates. . . . In the academic world, **Lee Bricker** has been named an Associate Professor of Medicine at the University of Miami School of Medicine. . . . Up at the University of Minnesota, **Huber Warner** has been promoted to Professor of Biochemistry. . . . **Dick Eller** is still with Electronic Arrays in Mountain View as Product Marketing Manager (he is setting some kind of record for longevity in the semiconductor industry employment annals) . . . Still on the west coast scene, **Bob Parente** has rejoined System Development Corporation as the Corporate Director of Planning . . . Another move for **Mel Copen**—this time to Westinghouse where he has been appointed director of strategic and economic analysis for the corporation.

Stan Klein is a New York editor for Business Week and sends word that "if any classmates have a good business story to tell, preferably with a technological slant, now's the chance to make use of an alumni contact." . . . Among the attendees at the last Alumni Day were **Dick Barone**, **Dan Holland**, **Ira Schwartz** and yours truly. Somehow, none of us ever saw all the others, so I'm taking the word of the sign-up sheet. . . . Although it is only mid-October as I write these notes, it is already cold enough here to put me in the mood to wish you all a happy holiday season with your family and friends. Get out on the cross country ski trails this winter and have an old-fashioned Christmas.—**Michael E. Brose**, Secretary, 30 Dartmouth Street, Boston, Mass. 02116

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Just a few introductory comments to emphasize the pattern we are trying to establish in having more communications from the class with periodic reports from our Regional Vice Presidents. The bulk of this month's column was prepared by **Phil Richardson** in New York. We are looking forward to hearing from many of our Classmates and we urge you to drop a short note to us at the addresses noted at the end of the column.

Phil writes: "It's hard for me to believe that only four months ago Charlotte and I attended the Class of '59's Fifteenth Reunion. It was shortly after we were back in New York City that I called **Scott Latimer** and suggested we have lunch. Scott works at American Smelting & Refining, a few blocks away from the bond trading floor at Lehman Brothers where I work. We had lunch at Harry's at Hanover Square and discussed many ideas for getting members of the class together, from luncheons, theater parties and banquets to cook-outs and sock-hops in Central Park. Anyone with suggestions please write me at home or call me at work (212-952-1575).

"During the summer we usually spend a few weeks at the Cape on Buzzards Bay in the small town of Pocasset. This year **Lloyd** and Dotty **Howells** mentioned that they would be on Martha's Vineyard for three weeks. So we packed our two boys into the rented car, drove out to Woods Hole and took the ferry to Vineyard. Lloyd, looking suntanned and healthy, met us at the dock. As things turned out, **Jerry** and Chris **Welch** were also there, having gone in together with Lloyd and Dotty on the house rental. Lloyd took us all for a drive during which Jerry found a tennis partner and the rest of us received a little sunburn and did a little sight-seeing.

"Shortly after we made it back to New York City I left for the M.I.T. Alumni Officers Conference. **Art Collias**, whom we had all missed at the reunion, was able to cut one of his extended travels short enough to make an appearance, as did **Allan Bufferd**, **Larry Bishoff**, **Dick Sampson**, **Ron Stone**, and **Bob McAuliffe**. **Jerome Schooler**, whom I last remember seeing in New York about ten years ago was registered for the conference from London, England. Unfortunately, I didn't see Jerry nor did I see two other registered conference attenders from our class, Dr. **John VanRaalte** and **George Heller**. Write and let us know whether you made it, guys, and what you're up to now. Hope I'll hear from or see all of you in the New York

area over the next year."

We have also heard from **Ed Cheatham** who has recently returned from an extensive trip to Moscow and was in the midst of packing with his wife and three children for a two to three year assignment in London to set up an international corporate public relations office. Hopefully, Ed and **Jerry Schooler** will be able to get together in London.

On the business front, Celanese announced the appointment of **William Golding** as Cleveland district sales manager for Celanese Chemical. After service with the U.S. Army Chemical Corps, Bill joined Celanese in 1962 and has worked in a number of the company's sales offices. Bill, with wife and son, has relocated to 1044 Morewood Parkway in Rocky River, Ohio. . . . **Joe Goodell** has noted that the column is lean unless some comments are forwarded and indicates that he has recently been elected Vice President of Chase Brass and Copper Company with major responsibility for their Williams County Division which manufactures brass rod and fabricated brass components. As the Chase representative on the Board of Directors of Nitto Metal Industries of Tokyo, a joint venture between Chase and Japanese interests, his frequent travel to Japan takes him away from his home in Bryan, Ohio, his wife, Margaret, and four daughters.

On the academic side, **Ron Stone** was recently appointed Associate Director of the M.I.T. Alumni Fund and is working the transition from his current position as Assistant Dean and Executive Officer of the M.I.T. Graduate School. . . . Also returning to the Institute is **Kenneth Garrett** as one of the fifty Sloan Fellows for the one year masters program. Ken, based in Encino, California, is Sales Manager for American Telephone and Telegraph.

Continuing the build up of academic credentials, **George Cronin** has recently received the Juris Doctor degree from American University. George, we would like to hear of your plans in combining an electrical engineering and law background.

One sad note was the information I received from the alumni office that **James McInnis** passed away on May 5.

Repeating our prior interest in hearing from the class, drop a short note to **Phil Richardson**, 180 Riverside Drive, New York, N.Y. 10024; **John Amrein**, 770 Greenwood Avenue, Glencoe, Ill. 60022; **Bob Muh**, 907 Chantilly Road, Los Angeles, Cal. 90024; **Adul Pinsuvana**, 49 Seri Road, Seri Village, Hua Mark, Bangkok, Thailand; or myself.—**Allan Bufferd**, Secretary, 8 Whitney Road, Newtonville, Mass. 02160

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A summer's worth of material to report. To start I have a card from **Gary Bickel** who continues the seemingly endless parade of Ph.D.s coming out of our class. Gary got his last March, in physics, from the University of Minnesota. Now he is working in Fiber Optics Communication at I.T.T. Electro-Optical Products division in Roanoke, Va. The Bickel's have two children: Geoffrey, who is six, and Kathryn, two. Congratulations, Gary. . . . **Stan Kulpa** also has a physics Ph.D. His came in 1968 and was from Brandeis. Diploma in hand, he then went into the army and was stationed in Washington, D.C. at the Harry Diamond Labs working in solid state. In 1969 Stan was mustered out but kept working in the same labs and set up house keeping with wife Linda in Chevy Chase, Md. Stan reports that he has a private pilots license. . . . **Clarke Swannack** is also a physicist and he writes: "Over the years my interests have followed the down staircase on the energy scale (particle physics—pion physics—nuclear physics—plasma physics) and my excitement increased accordingly. I got into fusion research two years ago at Cornell—learned plasma physics and built them a bigger and better Astron-type magnetic confinement device for 5 Mev electron beams before moving on to Los Alamos last fall ['73]. I am now plugged into the Scyllac, O-pinch program at L.A.S.L., and finally, since I'm living where the sun can be seen, I am doodling with solar energy power systems. I got my pilot's license in a single month and now enjoy buzzing the mountain peaks". Thanks for the letter, Clarke. . . . **Seymour Cromwell** is also into physics. He is teaching physics and math at the Groton School. He's also in the midst of a four year term on the Olympic Committee for Women's Rowing and on the National Men's Sculling Committee. He says that it is interesting that several major figures in U.S. rowing work for M.I.T. For example, the present and past chairmen of the Men's Olympic Rowing Committee are Ron Smith and Jack Frailey, while the head of the International Women's Rowing association is Gail Pierson. All three are M.I.T. employees.

Tom Ising was running for the Steger, Illinois school board last spring against two other candidates. I haven't heard the results, but have clippings from his local paper about the contest. The write-up mentions that Tom is a member of the board of the Prisoner and Community Together organization in Michigan City. The candidate is also quoted as being in favor of "the best possible education for all children". Hope you won, Tom. . . . Got a letter from **Marty Lorber** in which he wrote up his life in one neat paragraph:" Martin (Nipomnich) Lorber has become a new arrival to the San Francisco area, where he intends to begin private practice as a Board Certified Internist. He received his medical training at the University of Rome, Italy, and completed his internship and residency training at Montefiore Hospital in New York City (where he met his wife and was married about a year ago). I just passed through Boston on an Easter Vacation [this is an old letter] and must admit my amazement at the changes in both Boston and M.I.T. Yet there's no doubt in my mind that the people, weather, and the pace of life is much more comfortable here in the West [Secs comment: it's very dull to know what the weather will be in an hour out there in Cal.] . . . Also out West is **Alexander Ross** who writes that he is "Back in Hawaii and the area of personnel, organization and cost control, labor relations, fire and safety for Standard Oil of California. After assignments in engineering, refinery operations and management development, my wife and two children, who love it here, will be sorry to leave it again."

Ted Jarmain is still up in Canada continuing his cable television activities. Early this year his firm (whose name I forget) merged with another cable television outfit called Canadian Cablesystems Ltd and Ted is the combined operation's Executive Vice President. He and wife Pat and their three have moved to a new house in Toronto. . . . **Robert Ried** writes that he has been working on his new house. He says "I took a break from the routine to play carpenter with the interior and cabinet work for our new house. In spite of a gross underestimate of the work involved, I lost a few pounds and learned how to do it right for the next time".

A couple of other notes just handed to me: **Homer Schaaf** was admitted to partnership in the New York law firm of Brown, Wood, Caldwell and Ivey. . . . **Karl Josephy** is a senior research scientist at Continental Can. He is involved in the south shore neighborhood of Chicago where he has lived since 1969. Right now he is working on a "Wall Mural" project (whatever that is). . . . **Pete Fishman** writes: "I'm still with the government working at N.I.H. I am continuing my research on cell membranes and cancer. I identified a change in the membrane glycolipids common to cells transformed by various oncogenic agents (viruses, chemicals, X-rays); first part in a recent proceedings of the National Academy of Sciences. I spend about half my time in the lab with the other half writing." Wow! you must have a bundle of data, Pete.

Dick Naylor (or Richard Naylor as he is known to students) is forsaking M.I.T. this fall, leaving the Earth Sciences Department and crossing the river to Northeastern University where he becomes the Chairman of the Department of Earth Sciences. He writes that Northeastern is unusual among private Universities these days, in that it is in the black. He says that the Earth Sciences Department has a faculty of ten, and teaches about 2,000 students about the wonders of the world. About 60 students major in E.S. . . . Staying at M.I.T. is Associate Prof. **Gerald Wilson** who now occupies the Sporn chair of Associate Professor of Energy Processing. The press release sent out by the Institute mentioned that Gerry is known for his work on automatic load shedding and restoration during electrical power system emergencies. So it's all his doing! . . . Other news clippings tell of Craig Tedmon Jr., who received the Geisler Award from the American Society for Metals, an award which goes to the "outstanding member of the eastern chapter". . . . **Samuel Lord** is now an associate actuary at Phoenix Mutual Life Insurance. He has been a Fellow of the Society of Actuaries since 1971. . . . **Warren Wetmore** is now a planning analyst at Sybron Corp. in Rochester. The release doesn't say what Sybron makes, however. . . . Finally I report that the final estate of **Bill Shaw** included a large contribution to the Alumni Fund.—**Andrew Braun**, Secretary, 464 Heath Street, Chestnut Hill, Mass. 02167

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Lcdr. **Michael R. Terry** is presently associated with NATO Patrol Hydrofoil Program with Karl Duff, Class of 1958. . . . **James D. Miller** and his wife, Irene, and son, Chris, are moving to Santos, Brazil from Houston, Tex. His employer, Diamond Shamrock Chemical Company, is sending him there to be Plant Manager of the Carbo Cloro Plant in nearby Cubitao, Brazil . . . **Erik Pedersen** lets us know that he has recently moved back to the Boston area to start a new company in Kendall Square called Office Computer with George Berry,

V. E. Lysaght, '62

'65. They plan to offer turnkey minicomputer systems in the service industries. Initially they are working with travel agencies, printing airline tickets and doing all the accounting that goes with them. Heritage Travel is one of their first clients and, coincidentally, does most of M.I.T.'s travel. . . . **Bob Edelson** and his wife, Susan, recently celebrated their 7th wedding anniversary and the second birthday of their daughter, Sara. They now have a house in La Canada, ¾ mile from Jet Propulsion Lab and thus were able to sell their second car and Bob can now walk to work. He recently finished work as an Associate Member of Mariner Venus-Mercury Radio Science Team and was promoted to Supervisor of the Mariner Telecommunications Systems Group in charge of telecom systems design, implementation and development for Mariner Venus-Mercury and Mariner Jupiter-Saturn. . . . **Renwick E. Curry** is one of 30 promoted to Associate Professorship at M.I.T. He was appointed to the faculty in 1969 and resides in Hingham. . . . **Leland B. Jackson** has been appointed Associate Professor of Electrical Engineering at the University of Rhode Island. He will be teaching a course at the Naval Underwater Systems Center in New London, Conn., in digital filter synthesis, which is his area of specialization. He and his wife also have a new daughter, Anita Norton Jackson, who was born in January with Daddy present to see her arrive. . . . **Edward Maguire**, Director of Management Services for the New York Stock Exchange was named by the state of Massachusetts Dept. of Board of Education to the newly-established position of deputy commissioner for coordination. In his work as the new deputy commissioner, he will work towards improving the internal management of the department. He will be the Chief Operations Officer of the department and will work closely with the four program associate commissioners while reporting to the commissioner. He is married and has two daughters. . . . **P. Narayan Nayak** of India, formerly Assistant Professor of Mechanical Engineering from 1966-1969 will return to M.I.T. as Associate Professor in Mechanical Engineering for three years effective July 1, 1973. Dr. Nayak as been chief of technical services in the research and development department at Tata Chemicals Ltd. in India since leaving M.I.T. in 1969. . . . **Joseph F. Vittek, Jr.**, lecturer in the Department of Aeronautics and Astronautics and a member of the research staff of the Office of Sponsored Programs, has been named Assistant Professor in the Department of Aeronautics and Astronautics for one year. . . . **Peter Brown** has been named a principal and Executive Vice President of Audubon Properties, Inc., developers of The Country, a single-family community in Hollywood Florida. He and his wife and their two children live in Miami. . . . **Vincent E. Lysaght, Jr.**, has been named Plant Manager of Acco's new wire processing plant in South Bend, Indiana. He is a member of the American Wire Association and has been active in Kiwanis. He and his wife reside in South Bend, Ind.—**Gerald L. Katell**, Secretary, Rolling Hills Estates, Cal.

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October, 1974. Summer is gone and life is settling down for the long pull through the winter. The children are back in school, and in the east the leaves are turning. That's one thing I miss, living in California. I travelled east last week and drove through Pennsylvania and the West Virginia panhandle. Fall is the prettiest season in that part of the world. . . . A fair amount of Class news has accumulated over the summer which I'll be dribbling out in this and the next column. By the time this news appears in print it is old news . . . but, for the kind of news published in these pages a few months here and there doesn't make much difference. Who knows, maybe it improves with age, like fine cheese.

The Class of '63 was well represented at the M.I.T. Alumni Day festivities back in June. Those attending included class president **Garry Stone**, **Ron Matlin**, **Curtis Nordgren**, **George McDowell**, **Marty Schrage**, and Richard Soberman '61 . . . Two classmates praised your Secretary on his prose. **Steve Evans** wrote, "Dear Mike, Excellent job so far, keep up the good work." . . . Another note, culled from the flap of an alumni fund envelope read, "A note to our Class Secretary—must compliment you on the fine job you are doing." The latter was from **Mike Bertin**. (Just testing the communications channels—a note I wrote to myself in May gets published in December.) . . . I was cleaning out my magazine rack this summer and I came across the entire past year's issues of *Technology Review*. Having nothing better to do with my time that evening I made a survey of the classes of 1950-73 to determine their frequency of representation in the Class Notes section. On the average, 15 of the 24 classes are represented with a column in any given issue, and each column mentions 13.5 classmates. Three secretaries made all 8 issues, three made seven (including myself), five made six issues, and five made five. Two Secretaries made four issues, three made three, two made two, and one made one. In any case, this eased my guilt feelings about missing last May's column. Class Secretaries are actually doing a good job—16 out of 24 made more than half the issues and every class in my survey was represented at least once. Well, enough of this nonsense—let's forge ahead with last May's news.

David Juncker writes that Chad, his first child, arrived via the "Great Iron Stork" from Korea, and now Carol Louise has joined his family via the local flight path. Back in May, Dave was tooling up for the Sixth Annual Minnehaha Creek Canoe Regatta, and he issued an invitation for Classmates to visit Minnesota and canoe with him. In the light of the speedy publication of your invitation, maybe we'll make it for the Seventh Annual. . . . **Richard Boyd** brings us up to date on his recent history. He taught philosophy at the University of Michigan, Ann Arbor, (1966-67), University of California at Berkeley (1968), and Harvard (1968-72). In 1970 he got his Ph.D. in Philosophy from M.I.T., and is now an Associate Professor of Philosophy at Cornell in Ithaca, N.Y. His fields of interest include philosophy of science, logic, and the philosophy of the social sciences. . . . **Jerry Glaser** is now a Staff Engineer with the Space and Communications group of Hughes Aircraft in El Segundo, Cal. He is designing antennas for synchronous satellites and is giving a paper at the 1974 IEEE-GAP symposium in Atlanta, Ga. (Probably already presented.)

An interesting note from **Victor Scheinman** relates that he is President of his own company, VICARM, in Mountain View, Cal. VICARM manufactures robots and manipulators, and their main product is a mechanical arm. The arm, "Model M.I.T.", was developed at the M.I.T. Artificial Intelligence Lab. Vic is also on the staff of Stanford University. . . . **Richard P. Hervey** is also President of his own company—Sigma Associates of Mt. Clemens, Mich., a management consulting and venture capital firm. I am always amazed at how many M.I.T. alumni are in business for themselves. . . . **Mark Grebler** writes that he is working with **Bernie Hopp**, managing a fashion wig business. . . . **David Caskey** sends this note: "After filling these out two or three times, I'm not too motivated to do so again. I'll give a short one once more: I've been at Sandia Labs in Albuquerque since completing VI-A in '64. However, in '69 I took a leave of absence to return to school—this time at the

University of Texas in Austin. Despite "help" from a three year old girl, I managed to get my Ph.D. in electrical engineering in '72. The stay was highlighted by bigtime football (certainly a new experience for a Tech grad), and my own computer terminal in our apartment. Have now returned to Sandia, had another daughter (18 months and 6 years now), and devote 90% of my free time to landscaping a new house." Thanks for persevering Dave—you finally made it into print. And to all of you who sent notes in over the last six months—I still have them. They haven't been lost. I'll get them out in the next few columns. Just keep those cards and letters comin' in. Seasons greetings.—**Mike Bertin**, Secretary, 18022 Gillman St., Irvine, Cal. 92664

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Season's Greetings. Happy Holidays to you and yours from the four of us. It seems that a few of our classmates attended Alumni Day 1974 at the 'tute. Those present were **Edward Casper**, **Ronald Hersh**, **Richard Mayor**, and **Maury Shulman**. . . . **David Fahrland** was at the Institute this past summer lecturing for an Urban Systems Course. He is also working with Professor Larson in modelling police patrol activities.

It is with sadness that I report the death of another of our classmates, **Gary A. Lukis**. His brother informs us that Gary passed away one year ago.

We have been notified by the newsletter of the American Institute of Physics that **Lawrence Rabiner** has received the Biennial Award of the Acoustical Society of America. . . . **Mark Radwin** writes to tell us that he and his wife Karen are now the proud parents of a son, David, born last February. . . . As of this writing **Anthony Robinson** should be joining Baldpate Hospital in Georgetown, Mass., as a staff psychiatrist, and he is also opening a part-time private practice. . . . **Michael Stulbarg** (M.D.) informs us that he is now in private practice in Solana Beach, California, and also has moved to a new home near his practice. . . . Another Californian, **Don Cameron**, is with I.B.M. in Program Test. He and his wife Carole are parents of a young son. . . . Michigan State University is the destination of the **Hans Roland Zapp** family. Roland is an Assistant Professor of Electrical Engineering and his wife Roberta begins her studies at Medical School. They have two children, Alisa and Jon. . . . Please write and send some news.—**Steve Schlosser**, Secretary, 15 Apple Hill Road, Peabody, Massachusetts, 01960

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Those of you who don't read *Time* may have missed the news of **Ralph Cicerone**'s work in atmospheric research at the University of Michigan. Ralph has been in the forefront of the recent work on the effects of air pollution on the ozone in the atmosphere and his comments on spray-can freon were mentioned in the October 7 issue. . . . **John Holdren** is also in the professor business. John, at Berkeley, has been teaching three new courses in energy and environment. John's wife Cheri has raised the Holdrens' two kids to school age and received her B.S. in Zoology in August. She started an M.S. program in zoology in September. . . . **Rusty Bobrow** is back in Boston after three years of teaching computer science at the University of California at Irvine. Rusty was married in June to the former Susan Chase, who he met folk dancing at M.I.T. Rusty is doing artificial intelligence research at Bolt, Beranek and Newman and says its good to be back in Boston. . . . **John Butler**, on the other hand (or the other coast), is enjoying southern California. John is working in the process department of C. F. Braun and Company, construction and engineering contractors, on the first commercial scale oil shale refinery. John says that Southern California is heaven for rugby freaks (30-40 teams) and wonders "What's smog." . . . The **Doug Spreng** family is also enjoying California from their new home in Santa Rosa—in the country north of San Francisco. The first young Spreng was due in November. . . . **Tom Perrone** is a meteorologist with Oceanroutes, Inc. in Palo Alto. Oceanroutes provides navigation advice for merchant shipping. Tom lives in San Jose. . . . **John Woods** is also in California, working in an image processing research group at the University of California's Lawrence Livermore Laboratory. . . . **Mike Hester** is still with Lockheed in Burbank, where he has been since graduation. Mike has been a supervisor of scientific computer programmers since 1971 and completed his M.B.A. at Pepperdine last April.

On the east coast, **Bill Samuels** is in his fourth year as Vice President and Treasurer of MIND, Inc., an audio-visual education systems company oriented towards the needs of underachievers and the disadvantaged. Bill says the company's sales tripled in 1973 and that a European venture was launched in 1974. Bill was heavily involved in his father, Howard Samuels' campaign for Governor of New York. . . . **John Krause** is also in the east, working as an engineering specialist in ship silencing at the Electric Boat Division of General Dynamics in Groton, Conn. John lives in Mystic, Conn. with his wife and two daughters. John reports that he owns three motorcycles and is concerned about the government's imposition of uninformed "safety" regulations. (Let me tell you about 55 mph to save gas, John.) . . . Ellen and **Aaron Goldberg** are still in Framingham, Mass. with daughter Deborah (now 1½ years old). Aaron says he is very busy with the house and his work at G.T.E. Sylvania. He reports that the great suburban dream contains an even greater amount of sweat. . . . Even farther east is **Dave DeWan** who sent the Alumni Association a post card from Nepal. Dave is continuing a two-year trip around the world with visits to the Arab countries, the Middle East, and India.

John Freed reports that he received his Ph.D. in organic chemistry from Stanford in 1971, then spent two years on a postdoctoral appointment in immunology at the Stanford Medical School. Now John is at the Albert Einstein College of Medicine doing postdoctoral research on the biochemistry of transplantation antigens. . . . **Peter Sexton** completed his Ph.D. at the University of Aston at Birmingham, England, and has returned to Texas Instruments in Attleboro, Massachusetts . . . **John Martens** has finished his M.I.A. at Union College and is now with G.E. in Schenectady. . . . **Kayson Nyi** reports that he received his Ph.D. in organic chemistry from the University of Chicago in 1970 and was married to the former Corrine Hugh in June of that year. Kayson and Corrine now live in a suburb of Philadelphia, where Kayson is a research chemist at Rohm and Haas, and Corrine is a graduate student in physical chemistry at the University of Pennsylvania. . . . **Peter Heinemann** is finishing a Ph.D. as a Draper Lab Fellow at M.I.T. Peter is working in the applications of system engineering to health care.

Ameadeo Odoni and **Scotty MacVicar** were promoted to Associate Professor in Aeronautics and Astronautics, and Physics respectively, both at M.I.T. . . . **Jeff Meldman** has been appointed an Assistant Professor at the Sloan School. . . . **Cliff Weinstein** reports that he and wife Georgia (Ph.D.'72) had a daughter, Dana Evette, last June 4. Georgia teaches chemistry at Boston University and Cliff is at Lincoln Laboratory. . . . Sally and **Ray Fisher** had a daughter, Amy Cathleen, last January 15. Ray is still working on controlled nuclear fusion research at General Atomic in La Jolla, Calif. . . . And Gloria and **Jim Sprinkle** had a son, David Klizicki in December 1973. Jim is still at the University of Texas doing research on the earliest fossil echinoderms. His Ph.D. thesis was published in July, 1973 by Harvard's Museum of Comparative Zoology. . . . **Jim Bochnowski** reports the birth of a son, Thomas John, on December 14, 1973. Jim is still working in venture capital with Donaldson, Lufkin and Jenrette.

Finally, a note from your sponsor. A Reunion Committee has been formed, chaired by **Matt Mlezlva** to plan a Tenth Reunion for next June. It looks like we will have one day of activities in Boston on the Saturday following Alumni Day (now a Friday). **Jim Pepe**, **Dave Manalan**, **Steve Dangel** and I are helping with the plans. We are exploring the possibility of a parallel west coast reunion. Details in the next column. Related to the reunion plans is the need for new Class Officers. I think I'm involved with the nominating committee and certainly feel a responsibility to find a new secretary. So if anyone out there is interested in being Class Secretary for the five years 1975-1980, please write.—**Steve Lipner**, Secretary, 3703 Stearns Hill Rd., Waltham, Mass, 02154

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Meteorologists tell us that this winter will be among the worst in several years. If you find yourself snowed in sometime during the next few months, take the time to drop me a line. . . . **John Adger** has once again surfaced to let us know what he's doing: "We got tired of living a life of luxury and decided to join the ranks of tax-and-mortgage payers. I am working for the Federal Energy Office in incentives for synthetic fuels development. . . . We see **John Freeman** and **John Howard** fairly often; have seen **Richard Domerq** when he was in town on business." . . . **Michael Adler** reports "my wife Marcia gave birth to a baby boy on June 1, 1974; we named him Joseph. We are now living in our new house which we just finished building." . . . **Martin McGowen** and his family moved to Tustin, Cal., last June, where he is now working as a Senior Astrodynamist for Philco-Ford in Newport Beach. He has a new son, Martin James born last April.

Rafael Camerini-Otero and his wife have

J. K. Freeman, '66

moved to Washington, D.C. where he will be a Research Associate at the N.I.H. . . . **Bill Marion** has successfully defended his Ph.D. Thesis at the University of Texas and is now relaxing as a Post-Doctoral Associate at U.N.C. . . . **Terry VanderWerff** has left the University of Colorado in Denver after a year of cardiovascular research and is now in Cape Town, South Africa. He has accepted the appointment as head of the biomedical engineering activities at the world famous Groote Schuur Hospital. He invites all those passing through to stop by. . . . **Calixto Romero** has been named Assistant Professor of Medicine (cardiology) at the University of Chicago Hospital. . . . **Wilson Tang** has been promoted to Associate Professor of Civil Engineering at the University of Illinois. . . . **Alan Tobey** has finished his Ph.D. in Religion and Society at Graduate Theological Union in Berkeley. . . . **Thomas Groven** has married Isabelle Evenchick in Montara, Cal.

Stanley Horowitz is working on his dissertation on the Impact of Unemployment Insurance on Unemployment. . . . **Ralph Schmitt** and **Rich Lucy** are still building bathtubs. They say "two years later we're still not wealthy, but we have definitely learned that it's tough selling an oil-based product to the construction industry. Both supply and demand have fallen apart." . . . **Dave Penny** is working with a ready mixed concrete company in Geneva and working on improving his French. . . . **Dick Clark** is now an associate at the National Institute of Allergy and Infectious Diseases. At the end of his tenure in 1976 he will be "board eligible" and will return to Boston to finish his training at M.G.H. . . . **Charles (Rusty) Epps** is back in school again to get a J.D. in Law at the Hastings College of the Law in San Francisco. . . . **Bill Moss** received his Ph.D. in Mathematics last May and is now an Assistant Professor at Georgia Tech.

James Jackson has started a company in Marion, Mass. to work on computer applications and to consult in the area of engineering. . . . **Tom Percer** is back on the East Coast working for the Federal Government. . . . **Dennis Sivers** and his family are now living in Menlo Park, Cal. while he "dabbles" in high energy physics at S.L.A.C. . . . **Rob Wesson** is also located there with the U.S. Geological Survey. . . . That's it for now. See you next month. —**Tom Jones**, 59 Commercial Wharf, Boston, Mass. 02110

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Shar and I bummed around northern Europe for about ten weeks this past summer. We loved everything about our travels except the many inflated bills we collected. . . . **Avram Markowitz** writes from Israel where he is on the faculty of the Ben Gurion University of the Negev. He worked at Raytheon in Bedford, Mass. for two years after completing his Ph.D. in mechanical engineering at M.I.T. in 1971. Avram, Annette, and their son Barak left for Israel in January, 1973, but were planning to return to Boston for a working vacation late last summer. As a senior lecturer in mechanical engineering, Avram has been teaching design and heat transfer and has been involved in solar energy research. . . . **Frederick Keene** received his Ph.D. in math from Berkeley last spring and is now teaching at the University of Miami. He previously taught at Berkeley and University of California at Irvine in the land of Disneyland. Fred is engaged to Jane Earl Crittenden of Oakland, a teacher in the Oakland public schools. The wedding will be in late December, and any Tech tools planning to be in the San Francisco area at that time should contact Fred. . . . Nancy and **Robert Gerstle** announce the birth of their second child, Amy Sara, born May 21, 1974. In July Robert entered pediatric practice in Springfield, Mass. . . . **Dave Schramm** has accepted a tenured Associate Professorship at University of Chicago. The joint appointment is with the Department of Astronomy and Astrophysics and the Fermi Institute for Nuclear Studies. . . . **Dana Ballard** is spending the year in Rome at the Laboratorio Technologie Biomeche. He received his Ph.D. in engineering last June from University of California at Irvine where his dissertation was entitled "Hierachic Detection of Tumors in Chest Radiographs." Dana is married and has a two-year old son. . . . The following classmates attended Alumni Day 1974: **John Acevedo**, **Mike Dunlavey**, **Gary Garmon**, **David Hill**, **Felipe Pradas**, **Ed Radlo**, and **Phillip Rosenkranz**. . . . **Gregg Heacock** is going after his M.B.A. at Harvard Business School and working as Assistant to the President at Danforth Associates in Wellesley. . . . **Terry Collins** is planning to receive his Sc.D. in electrical engineering from George Washington University in 1975. He spent considerable time last year in the United Kingdom and Japan. Terry and Alisann have a baby, Katherine, born January 8, 1973. . . . **Melvin Snyder** is in his third year of neurosurgical residency at U.C.L.A. He has a two-year old son, Jason. . . . Myrna and **Bob Karz** have a one year old daughter Sara Gail. . . . **John Podolsky** is with Hughes Aircraft. . . . **James Gips** received his Ph.D. in computer science from Stanford last April and is now at U.C.L.A. . . . **Mike Zuteck** is working at Earth Resources in Houston, Texas. For the sailors, Mike finished second at CORK and ninth in the Worlds in the Tornado class. . . . **Gerry Siegel** left Exxon to direct operations research applications for Hess Oil as supervisor of Technical Systems Division. He has a home in Belle Mead, N.J. . . . **Henry Heines** has entered Golden Gate University School of Law in order to combine a law degree with his doctorate in chemical engineering and enter the field of patent law. He is still working at Stauffer Chemical. . . . **Jesse Mase** happily teaches math at Shadyside Academy, a prep school in Pittsburgh. At last report, Jesse was planning to spend the summer in the wilderness of Maine. . . . After too many years in Maryland, Linda and **David Bailey** and their child Colin have returned to New England. They bought a house in the boom town of Merrimack, N.H. . . . **Jerome Milch** received his Ph.D. in political science from M.I.T. last February and is now in the Program on Science, Technology and Society at Cornell University. . . . Bachelor **Bruce Barron** has sold his plane and purchased a Porsche and a Honda. . . . **Bob Schwartz** ended his student status by receiving a Ph.D. in mathematics from University of Pennsylvania. Bob's faith in a Philadelphia hockey team paid off as the Flyers picked up the Stanley Cup. . . . Sandra and **Stephen Metz** and their two sons live in Oxon Hill, Md. Stephen works at the Naval Research Lab in Washington. . . . **Mike Schiff** and Kathy McCall were married June 8, 1974.—**Jim Swanson**, Secretary, 669 Glen Rd., Danville, Calif. 94526

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We have just a small pile this month as the winter starts to descend on our nation's capital. First we start off with a long letter we got from **John Vitek**. He reports that August 1973 was a very busy month for the Vitek family. The day after he completed his oral defense for a doctorate in metallurgy for the 'tute, he and Marty had their second child, Sarah. After a few more less hectic months in Massachusetts, they moved to Germany where he has a two year postdoc with the Max Planck Institute ("another institute!") in Stuttgart in the area of material science. Last spring they visited Czechoslovakia, Austria, and France and this fall they plan to visit Spain. John writes, "We are adapting to life in Germany fairly well, although only now am I feeling a bit confident in German. Wouldn't you know, I took French in high school and at M.I.T." . . . John reports that Holly and **John Yasaitis** are in Karlsruhe, Germany where he has a one year postdoc and that **Mark Fidelman** has been studying for a Ph.D. in Biophysics at the University of Buffalo after getting an M.S. in physics at Purdue. . . . **Eric Schuetz** is "having the great life of a bachelor living down on the beach in Southern California". His job gives him lots of travelling around the country. Last year he spent two weeks on a vacation in Hong Kong and Bangkok. . . . **John Dehne**, his wife Carol, and their 2 year old son Phillip Andrew are now living in Woodbridge, Virginia. He works for the Army Night Vision Laboratory and is responsible for the development of computer aided design tools for use in the design of night vision equipment. He is also responsible for the application of automatic pattern recognition and image enhancement technology to night vision equipment. . . . We hear from **Scott Mermel** that he recently was promoted to Installation Manager with Xerox Computer Services in Chicago and has bought a house in Arlington Heights, Ill. He reports that **Ron Bohm** recently added a second son to his family and has bought a house in Miami and that **John Kasarda** has moved to D.C. and recently bought his own airplane. . . . Having

received a Ph.D. in planetary science at M.I.T. a couple of years ago, **Richard Greenberg** is now doing research in the Lunar and Planetary Lab at the University of Arizona. . . . Finally, **Gerald Gilliland** has a new position as Chief Engineer for Pelton Steel Castings Co., Milwaukee, Wisc. . . . That's all we have for this month, drop us a line and you can make the big time.—**Gail** and **Mike Marcus**, Secretaries, 2207 Reddfield Dr., Falls Church, Va. 22043

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Seasons Greetings! I have received only a handful of letters since the last installment of our class notes. Take time out this holiday season and drop me a note. . . . Professor **Alan S. Willsky** has been appointed assistant director of the M.I.T. Electronic Systems Laboratory (ESL). His primary responsibility is to coordinate research in the theory and applications of the Decision and Control Sciences area. After receiving his Ph.D. from M.I.T. in aeronautics and astronautics in 1973, Alan was appointed an Assistant Professor of Electrical Engineering. He has written a number of papers on the use of Lie group theory and harmonic analysis in the design of estimation systems for such applications as synchronous communication and satellite attitude control. Alan is also the author of several papers in the field of automata theory. While assuming his new responsibilities with ESL, he is continuing his work on a Lie-theoretic-harmonic analysis approach to filtering theory and is also involved in the development of "Fault-tolerant" control system design techniques and in the design of control techniques for large-scale data communication networks. Alan and his wife Gail Fleischman, '70, live in Eastgate.

David W. Levine has been selected to receive a fellowship from the newly established M.I.T. Health Sciences Fund. David is applying an engineering approach to the development of a new technique for the growth and culturing of normal human cells. . . . For those of you who remember the press conference this past summer at which Secretary of State Henry Kissinger engaged in angry exchanges with members of the press concerning his alleged role in White House efforts to plug leaks of national security secrets, including FBI wiretaps of government employees and reporters, you may be interested in knowing that the initial question regarding these matters was made by **Peter Peckarsky**. . . . **Gregory C. Fox** and **John D. Fernstrom** have received Sloan Research Fellowships. Gregory is currently in the physics department at California Institute of Technology while John is currently in the neurochemistry department at M.I.T. . . . **E. M. Waibel** is providing public and private sector management consulting services as an associate in the management services division of Touche Ross & Co. While his position offers numerous opportunities to sharpen skills he obtained while working for his M.B.A. at Harvard Business School, he has undertaken engineering consulting engagements on the side to remain proficient in technical areas. He is also pursuing a P.E. registration in Washington, D.C. In closing, he states that while a capitalist at heart, he "still seeks venture in which to commit myself. My recent trip to Asia (fall 1973) has given me numerous ideas but has precipitated no action on my part." . . . Since February 15, 1973, **Mark A. Wuonola** has been involved in a project directed toward the completion of the total synthesis of vitamin B-12 under Professor R. B. Woodward, '36, Ph.D. '37. Next year when he leaves his postdoctoral position, he will assume a position with the central research department of DuPont in Wilmington, Del. . . . **Carl R. Bozzuto** and his wife are the proud parents of a baby girl, Mary Alexandra, born on January 12, 1974. . . . **Michael E. Warren** completed his work towards his Ph.D. in electrical engineering and received his degree in June 1974. He is now an assistant professor with the Department of Electrical Engineering at the University of Florida, Gainesville. Although he enjoys the Florida sunshine, teaching and other aspects of his position, Mike writes that he misses the intellectual fervor of M.I.T. and the cosmopolitan culture of Boston. He also misses the snow as his skis are getting rusty. Mike and his wife Phyllis have another son, Jeremy, born on May 2, 1974. . . . **Sam Leader** is enjoying the pleasures of the Far East while working in Hong Kong for First National City Bank. Sam travels extensively while working on new computer systems throughout Asia. . . . **Dennis Keane** completed his four year tour in the U.S. Army in August 1973, including three years as a systems analyst at the Army Materiel C.M.D. in Washington, D.C. and one year as a contracting officer in Saigon where he also received a bronze star. He is now in pursuit of his M.B.A. at the University of Southern California where he is also teaching undergraduate courses in operations research for the U.S.C. Business School. He worked this past summer as an administrative assistant for the city of Inglewood, Cal. His wife Joan is an administrative assistant for the U.S.C. Center for Laser Studies. Their daughters Sandra and Tania are now five and three years old, respectively. . . . After spending two years in Germany with the U.S. Army, **Richard A. Pinnock** was released from active duty in May 1973. Last September he returned to M.I.T. and has now completed two semesters of study towards his engineer's degree in nuclear engineering. In June of this year, Richard started a graduate coop job through the M.I.T. nuclear engineering department with Boston Edison's nuclear department. . . . All for now.—**Richard J. Moen**, Secretary-Treasurer, 4008 IDS Tower, Minneapolis, Minn. 55402

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Believe it or not, it's been nearly five years since we graduated (well, most of us, anyway), which means that the time is rapidly approaching for our class's fifth year reunion. By the time you read this, you will have received from me a letter and questionnaire asking, first of all, if you are interested in having a reunion, and secondly, for suggestions and for volunteers to work on a reunion organizing committee. Alumni Day is scheduled for Friday, June 6, 1975, so reunion activities would take place that weekend. The reunion would be held primarily on campus, largely to hold down costs; M.I.T. will provide rooms free of charge. Please keep June 6-8 in mind, and return the questionnaire to me; whether or not we have a reunion, and what form it takes, is up to you. (To those of you who may not receive a questionnaire—the list of class members is not completely accurate—my apologies; please write and let me know your thoughts.)

T. M. Devine Jr., '70

And now for some news: **Stephen G. Smith** is still a management consultant in Holland, and now has two children. (Are those two statements related?) He and his family will probably move soon to either Brussels or London. . . . **Mitchell Serota** spent last year in Paris as a French Government scholarship holder. He's now in the writing stages of his doctoral dissertation in history for the University of Chicago. . . . **James F. Pelegano** is in his third year of five at the University of Rome. He was home for the summer, working as an extern at St. Mary's Hospital in Utley, Conn. . . . **David A. Erickson** is working as a chemical engineer for P.G. & E. Moss Landing Power Plant and is living in a little house in the Carmel (California) woods with his wife Sue, who is a second grade teacher. . . . **Paul Doherty** is currently an Assistant Professor of Physics at Oakland University in Rochester, Michigan. Paul graduated from the Institute in June with a Ph.D. in physics. . . . **Laurie Nisonoff** is an Assistant Professor of Economics at Hampshire College. . . . **Chester H. Conrad** is one of five M.I.T. graduate students who has been selected to receive a fellowship from the newly established M.I.T. Health Sciences Fund. Chester is studying the elucidation of mechanisms of certain important cardiac arrythmias; he is associated with the Elctrical Engineering Department and the Harvard-M.I.T. Medical Program. The fellowship, which is for a 12-month period beginning last September, pays full tuition and carries a stipend of $3600. . . . Effective last July 1, **James M. Lyneis** was named an Assistant Professor at the Sloan School for three years. James received two undergraduate degrees from the Institute in 1971, in electrical engineering and in management, and a Ph.D. in business administration from the University of Michigan last summer. . . . **Thomas M. Devine, Jr.**, is a metallurgist with the General Electric Research and Development Center in Schenectady, N.Y. Thomas received his master's and Ph.D., as well as his bachelor's, in metallurgy from M.I.T. . . . **Bill K. Wong** has been appointed an Assistant International Banking Officer of Marine Mid-

land Bank, New York. Bill received an M.B.A. from New York University in 1973 and began working at Marine Midland in July, 1973, as a management associate. Since September 1973 he had been a territorial assistant in the Asia-Pacific region of the International Banking Department of Marine Midland. . . . Nepotism Dept.: **Deborah Bovarnick**'s brother Daniel is a freshman at the Institute this year.

This month's mailbag award goes to **Kurt Klinzing**, who sent in a rundown of what has happened to our class's Phi Mu Delta contingent. Kurt graduated in 1971, flunked his army physical, wandered out to California, wandered back to Boston, worked two jobs for two years, got sick of computers, and left for the Dominican Republic, where he is staying with Fabio J. Guzman, '73. Kurt purports to be writing a book entitled, *How Not to Learn Spanish in a Foreign Country*, soon to be released under the name, *The 100 Year Old Wiseman.* Fabio, who finally graduated in 1973 with a degree in history, is tending some 250 cattle on his ranch. . . . **Richard Vogel** has disappeared into the great central desert of Australia, where he was reported to have been tracking satellites. . . . Richard Owens, Jr., '71, is working for Management Services for Health in Cambridge, where his major concern is birth control. . . . **Steven A. Pettibone** is working for Data General and is living in North Cambridge. Steve, who has a B.S. in philosophy and a B.S. in math from the Institute and a M.A. in philosophy from York, "will be studying the ontological implications of table driven compilers and their possible use in alleviating the general angst which is now afflicting mankind." His wife, Mary, has just received a degree in Library Science. . . . Jeff Beck, '71, living in Boston's suburbs, is working for Honeywell. . . . Edward Black, '71, is still working for Project MAC. His wife, Bunnie, is in her second year at Boston University studying for her R.N. They and their child, Jennie, live in Brookline. . . . Barney Black, '71, has become a professional skindiver somewhere in Chesapeake Bay. . . . **Arnie Epstein** (not a member of the PMD contingent) has a job as a computer trouble shooter in Europe. . . . That's all for this month. Think reunion!—**Laura Malin**, Secretary, 82 Munroe St., Apt. 1C, Somerville, Mass. 02143

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I got a fine letter from **Steven Shantzis**. "After graduating in course VIII, I left for Washington where I worked with a consulting firm in Educational Finance. One of the high powered groups of all M.I.T. and Harvard Business School people—small and specialized. It was great work but I didn't dig Washington so I came out to sunny California to do graduate work in Engineering-Economic Systems and took my Master's degree in June. I am currently doing free lance consulting in Energy Conservation systems and brokering yachts in San Francisco. I'd like to talk to classmates in the Bay area and can be reached any day at Albatross Sailing Centers."

In the line of random notes: **Bob Schulte** spent last year working at Gillette in Southie and is back at the Harvard Business School this year. . . . **Herb Newborn** was working at Raytheon on materials for laser windows and returned to the Institute to work on a doctorate in course III this fall. . . . **John Scalea** is a doctoral student in flight transportation at M.I.T. working on supply and demand for various levels of service in commercial airlines. He was married in August to Ann Marie Marion, an Emmanuel graduate. . . . **Lenny Colakis** is working for a shipping company in Athens. . . . **Jimmy Chang** is studying plasmas in the Nuclear Engineering Dept. at the University of Illinois. . . . **Joel Bergman**, '73, is working for Blue Cross Blue Shield.

Wendy Erb wrote about a number of classmates: "I survived my first year at Stanford Law School. I'm currently (July) working for Jaffe, Snider, Raitt, Garratt, & Heuer in Detroit. (Ira Jaffe is class of '61, I think). I'm working hard, but enjoying it a lot. I plan to quit in mid-August to take a weeks trek through the Sierras. . . . **Ed Rich** is also at Stanford Law. . . . **John Gunther**, who has been traveling around the country with a friend since January, dropped into the Bay area right during exam period. He's having a good trip hitting about every national park there is and having his share of misadventures. . . . Earlier this spring David Dobkin, '70, came out for a conference, **Kathy Kram Dobkin** stayed home working at Aetna. They have what sounds like a beautiful spot to be living in Cromwell, Connecticut. Wendy continues, "I hope to continue with Legal Aid in the fall, but I'm not sure how to balance out enough time for it, law review, school, and getting away to the Sierras and Ocean. That's all I know except for the mundane things like breaking and dislocating my toe. (You wouldn't want to know how that occurred.)"

Marty Shinko, a fellow M.E. also wrote, "I'm still at Bettis Atomic Power Lab. I'm working in the Light Water Breeder Reactor Project doing work analysing the postulated Loss-of-coolant accident. The reactor ought to be installed at Shippingport within two years and is cheaper, cleaner, and closer to operation than any other breeder concept. Shippingport is being upgraded with a newer Safety Injection System. The plant will be safe but you don't have to take my word for it. Read the Safety Analysis Report when it comes out I'm writing section 15.1.13. . . . As for other Class members, **Steve Saunders** is alternately doing graduate work at Carnegie Melon University in Pittsburgh and working for Xerox in Mountainview, California. . . . **Winston Edmond** is working in Boston for Bolt, Beranek and Newman. . . . **Bob Kilcup** is working at United Engineers in Boston. Bob is doing structural engineering for a power plant which Rochester electric will be building." —**Dick Fletcher**, Secretary, 135 West St., Braintree, Mass. 02184

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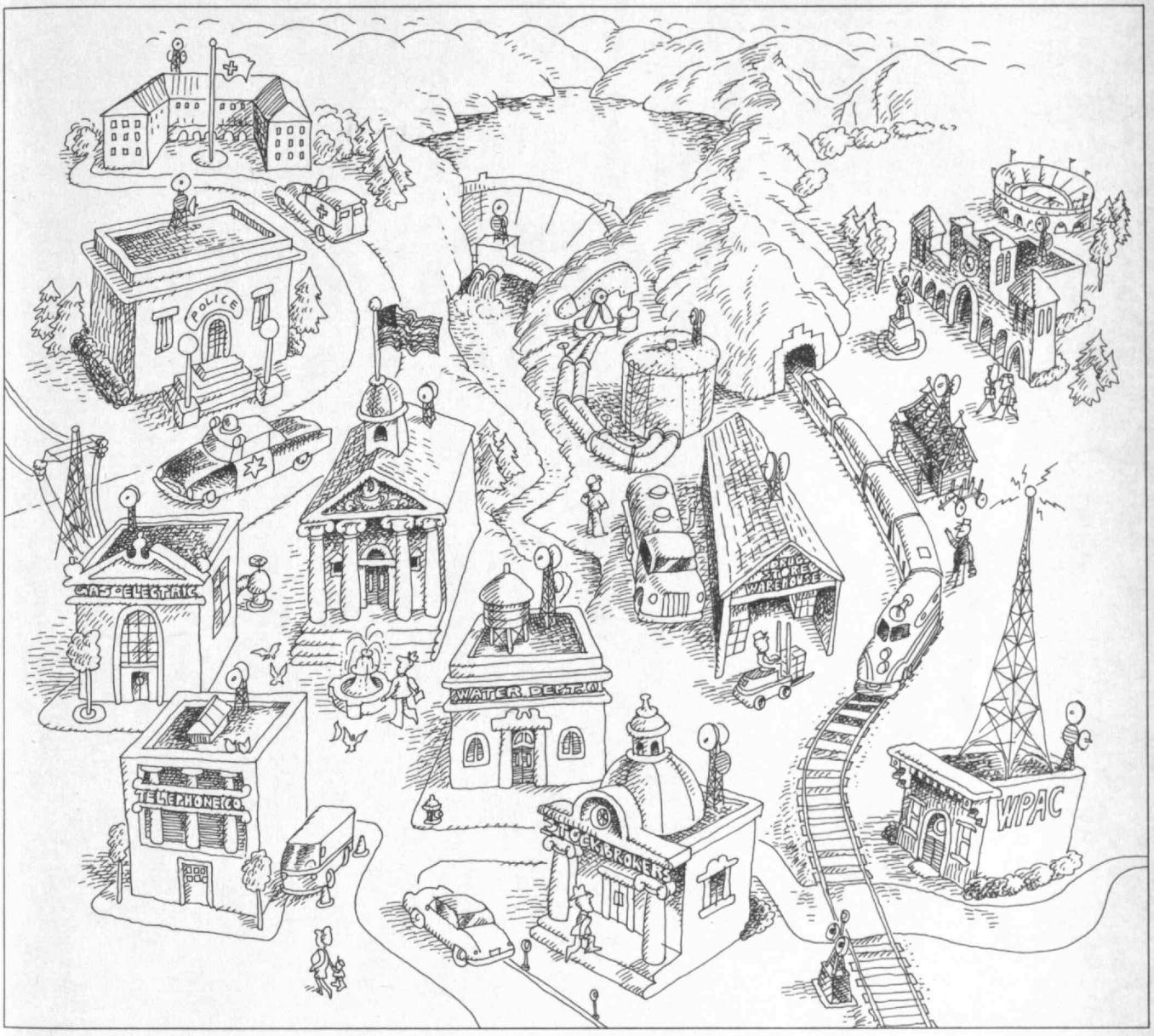
Excitement—I attended my first M.I.T. Alumni Officers' Conference in September of this year, which is the Centennial year of M.I.T.'s Alumni Association. It was an interesting conference, considering that everyone was not as old as one might expect nor was everyone in the technical and science professions as one might expect nor was everyone an alumni officer as I did expect. At the Alumni Dinner I met many current M.I.T. undergraduates who get invited to many Alumni functions. This, by the way, is a good thing—the best input alumni can get is from the students and vice-versa. So, I was surprised, but glad, that the students were there. Dinner was not in Walker Memorial as planned, however, for the Physical Plant and Dining Service staffs were on strike at the time of the conference. As I write this, the strike is being settled. It did make the news, so you may have heard about it. The dinner was at the Statler Hilton in Boston where Luis Ferre '24, Governor of Puerto Rico, Alumni Association President, presided over the ceremonies. The next morning in Kresge Auditorium was the conference itself, where a preliminary report on the M.I.T. Alumni Survey was made. Afterwards, the audience adjourned to the Student Center where they met in smaller groups to discuss the results of the survey. One problem raised was the inability of many older alumni in attracting the interest of younger alumni in M.I.T. Alumni Association events. If you have any suggestions, please write them to me and I will forward them to the correct person in the M.I.T. Alumni Association—or send your suggestions directly to the editor of *Technology Review*. I found the Centennial Conference enjoyable and look forward to future conferences. Interestingly enough, of the two dozen or so students I saw at the dinner there were only three who I saw attending the conference the following day. I also noticed that a copy of *The Tech* was included in the information packet for alumni officers, but copies of *Thursday* and *Ergo* were not. Another tidbit I found interesting was that most of the jokes said by speakers during the dinner and the conference were either anti-Harvard or sexual in nature.

At the conference dinner I met **Paul Schindler** who is working on an alumni project for *The Tech*. Paul is currently working for the Associated Press in Boston as a wire service reporter. His plans for the foreseeable future include living in the Boston area and permanent employment in professional journalism.

There is other news of classmates I was told of at the conference dinner. Our Class President, **Derrick Vlad**, is attending the University of Chicago for a Masters in Business Administration after returning from a summer vacation traveling in Europe. . . . **David Fox** is attending Harvard Medical School. . . . **Mike Glenn** and **John Daly** are going to Michigan Law School. . . . Another law enthusiast is **Andrew Jaglom** who is going for his law degree at Harvard Law School. Drew says that the work is of a much greater volume than the work he had at M.I.T., but he is still enjoying himself.

Jeffrey Alexander is at M.I.T. working towards a master's degree in electrical engineering. He has been awarded the Schlumberger Foundation Fellowship in the E.E. Department for this school year. . . . After traveling across the country to California in a VW van this summer, **Jim Gokhale** is back in Cambridge working at the Charrette Corporation. His plan for now is to live in the Boston-Cambridge area doing free-lance design work for developers and architects. . . . Among new M.I.T. freshmen for this year are **Mary Bradford**'s brother Richard and **Joel Rubin**'s brother Stan. . . . There may not be much news, but you can rely on me to stretch it out. Keep those mailgrams and picture postcards coming.—**Dennis Dickstein**, Secretary-Treasurer, 23 Howard Street, Cambridge, Mass. 02139

If having your own microwave communication system sounds like something out of the 21st century, take a good look at today's world.



The illustration shows some of the ways people are using private microwave systems today.

For example: railroads use microwave to monitor and control what's happening on thousands of miles of railroad track.

Medical schools use microwave to bring televised procedures from distant hospitals into the classroom.

Oil companies use microwave to control pipeline flow, and monitor production at well heads.

Utilities use microwave systems for remote supervision of energy generation plants and distribution networks.

And the list of users and potential users goes on. Through law enforcement agencies, schools and industry, highway departments, water districts, telephone companies, broadcasting companies, retail chains, stock brokers.

The point is, microwave can do a lot of things. And the opportunities for private use are just now beginning to be explored.

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GTE LENKURT

Stan Kaufman Fights Water With Jelly...

to keep people talking. Bell Labs chemical physicist Stan Kaufman invented a material that turns waterlogged underground phone cable into a water-free "jelly roll" that can carry calls again. Pumped through football-field lengths of cable as a liquid, the material forces water out and then turns to jelly—to keep the water out.

Water sometimes seeps into cable damaged by plows, lightning, gophers, or sharp rocks. Phone calls going through the cable become noisy or don't go through at all. Until now telephone companies had to abandon waterlogged cable, or dig it up and replace it, or use acetone to flush out the water. Once the acetone was evaporated, however, there was nothing to prevent water from getting back in again.

We needed an inexpensive water-repellent liquid that would turn into a jelly inside a cable and plug up holes. The material also had to be electrically nonconductive so it wouldn't interfere with telephone signals. Such a material didn't exist, so we asked Stan Kaufman, a 1970 Ph.D. from Brown University, to tackle the problem.

Drawing on his knowledge of molecular structure and working with telephone company engineers—sometimes in muddy cable trenches—Stan came up with a new compound. A Western Electric engineer modified a pump to force the compound through long lengths of cable. And during field trials, operating telephone engineers suggested installation procedures.

Bell Telephone companies are happy because they don't have to dig up as much waterlogged cable, which often runs under highways and people's lawns, and because restoring an otherwise good cable helps hold down the cost of providing telephone service.

Bell Labs

From Science: Service